

CEP

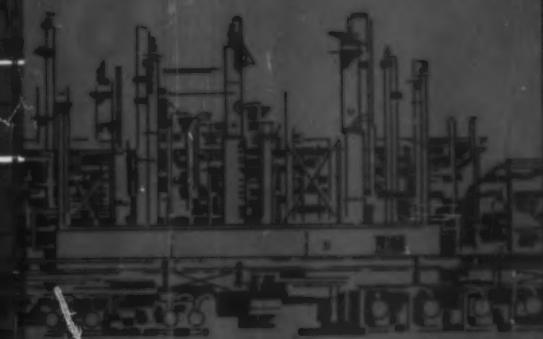
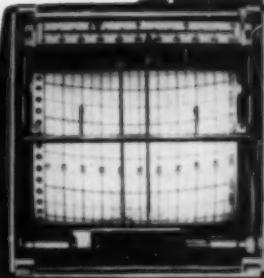
CHEMICAL ENGINEERING PROGRESS

JULY 1969

Controls

for continuous
distillation

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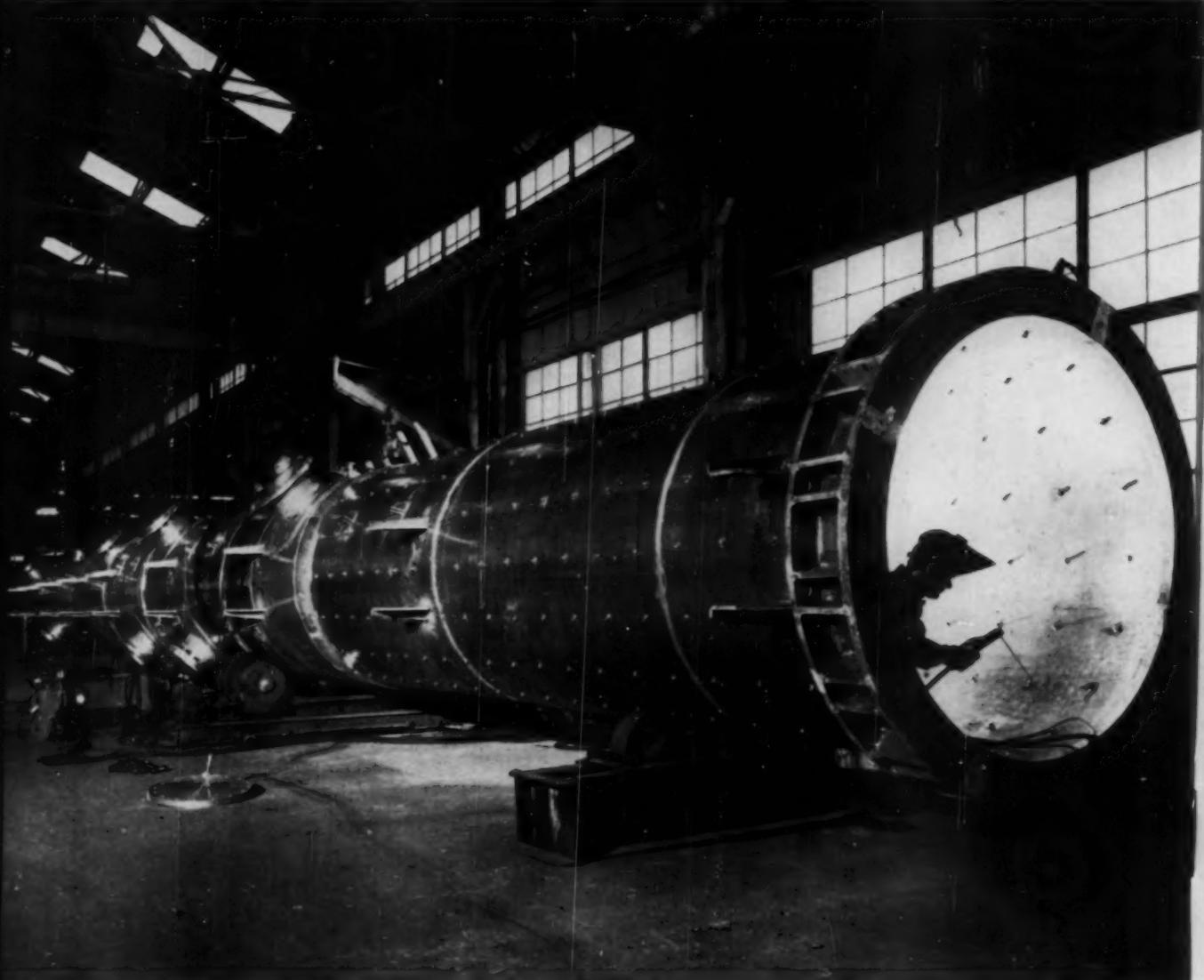
PLUS:

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Cover by Paul Artt. Halftone reproduction of a Forbora Control record control and a depiction of the distillation plant at U. S. Steel's Coke and Chemical Division Gary (Ind.) Works.

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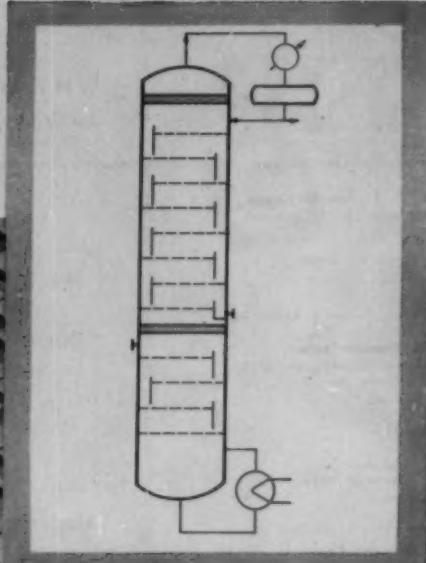
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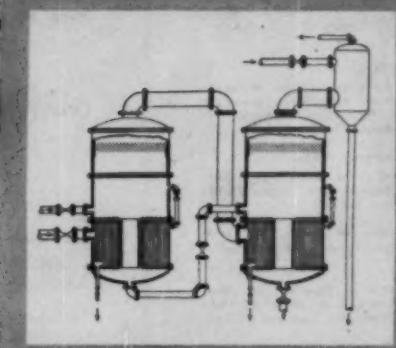
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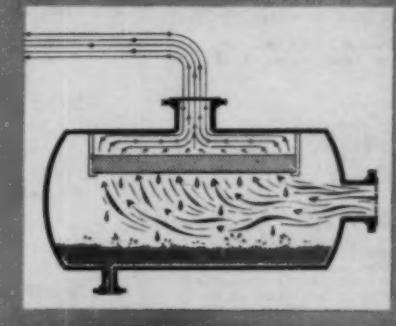
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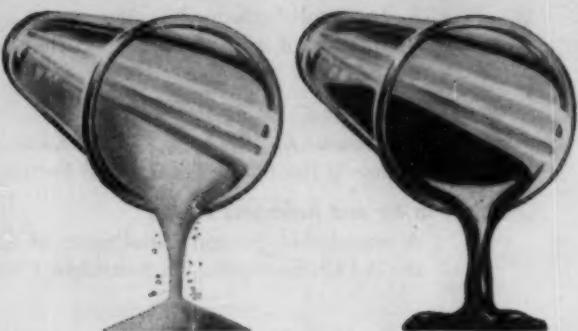
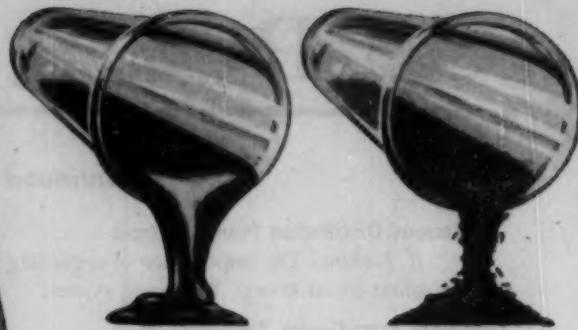


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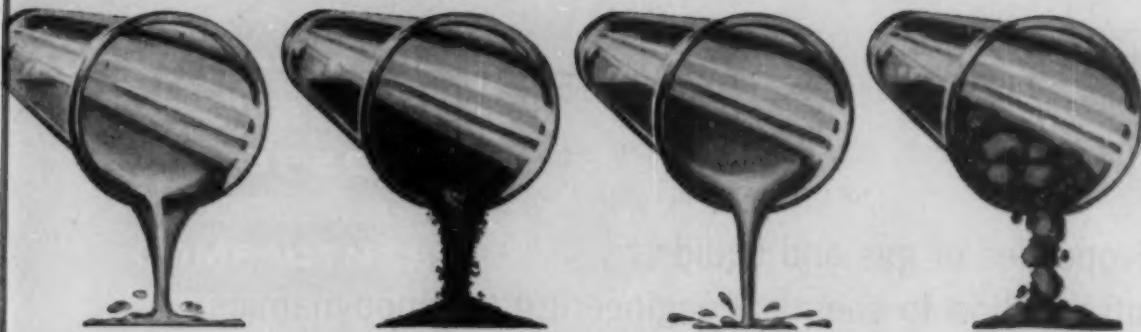
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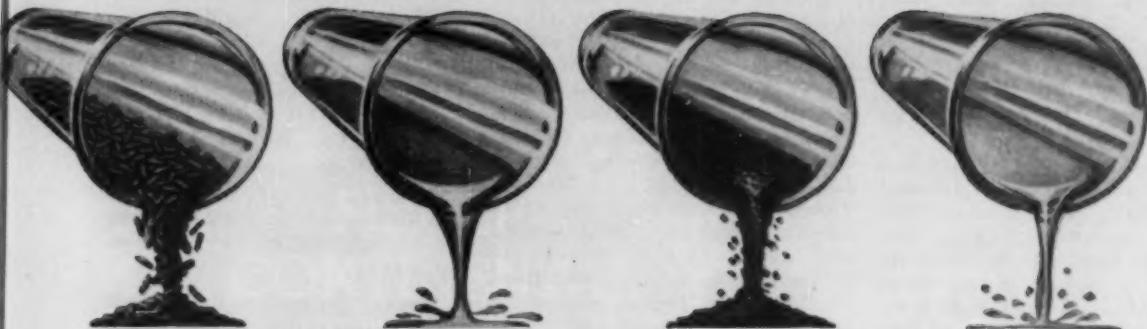
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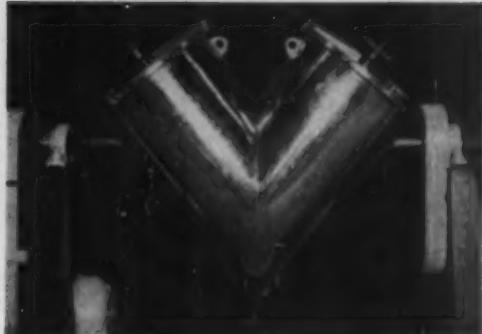
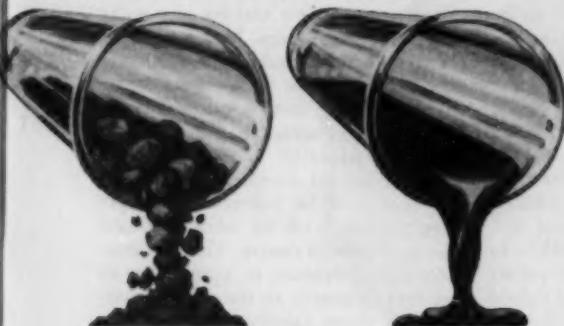
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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959

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Properties of gas and liquids, introduction to chemical engineering thermodynamics, subjects of new books

THE PROPERTIES OF GASES AND LIQUIDS, R. C. Reid and T. K. Sherwood, McGraw-Hill Book Co., New York, N. Y., (1959), 386 p., \$10.

Reviewed by J. W. Riggle, Engineering Research Laboratory, E. I. du Pont de Nemours & Co.

This book consists of eight chapters in which procedures are presented for correlating and estimating the physical properties of gases and liquids. An initial introductory chapter includes explanations of format of the book. Each chapter (with the exception of the introductory chapter) discusses means for correlating and estimating a specific property; for example, Chapter 8 is entirely concerned with viscosity of liquids and gases. The properties included are: critical properties; P-V-T relationships; vapor pressures and latent heats; heats, free energies of formation, and heat capacities; viscosity; thermal conductivity; diffusion coefficients; and vapor-liquid equilibria. An excellent bibliography is also included which contains 480 literature references.

A unique feature of the book is that each chapter is a separate, complete book in itself with a format that is identical to every other chapter with the exception of the introduction. In each chapter the authors first present a brief description of the chapter's contents. Then they give a word picture of what the particular property is and describe general methods for measuring it. Next, the correlating or estimating procedures are clearly presented. Finally, recommendations for the best procedures are presented in order of descending preference. The entire book is liberally sprinkled with extensive tables containing data for use with each procedure. Tables are also used to clearly show the errors found in the use of the various procedures.

A refreshing and welcome feature of the book is an attempt by the authors to present the reader with a handy "cook book" for getting the end result—a property for use in subsequent calculations. In no case is the reader left in doubt as to what equation to use or how to use it. In fact, where lengthy equations are necessary, the steps for a complete solution are listed with short cuts liberally included to save the engineer-reader time in making calculations. In many cases, thermodynamics are required to understand and use the procedures. The authors have clearly and quickly presented the necessary thermo background in a manner which should be copied by future thermodynamics book writers.

This book contains information of great value for all practicing chemical engineers, but it will have to be continuously revised as new correlation and estimation procedures are presented. It looks like provision should be made now so that when a suitable time has elapsed (five years, perhaps), a second edition will be available. Already several developments have been omitted which should be included in a future edition. For example: (a) more emphasis might be placed on use of computers although slide rule calculations should not be omitted; (b) the whole field of non-Newtonian behavior of fluids should be included in the viscosity chapter, if possible; (c) diffusion in high polymers where the diffusion coefficient varies several-fold should be mentioned; (d) total pressure techniques for obtaining vapor-liquid data should be evaluated.

Summing up Reid and Sherwood's book: (a) a gap has been filled in the chemical engineering literature; (b) a different style of technical writing has been used that exactly suits the purpose of the book; (c) a high level

of technical excellence is maintained for the engineering world.

INTRODUCTION TO CHEMICAL ENGINEERING THERMODYNAMICS, J. M. Smith and H. C. Van Ness, McGraw-Hill Book Co., New York, N. Y. (1959) 490 pp.

Reviewed by Dr. Charles M. Thatcher, Chairman, Chemical Engineering Department, Pratt Institute, Brooklyn, N. Y.

The changes made in this new edition of the earlier text by Smith appear to be all for the better, and the result is an introductory text which is at once adequate in scope, consistent in depth of treatment, and, most important, written with commendable clarity of expression. As such, it can be recommended as a reference or review text for any engineer with some prior background in thermodynamics, and might even suffice as a basis for self-instruction in the absence of any prior familiarity with the fundamental principles of thermodynamics.

This does not mean, however, that the book will be universally acceptable for use with an undergraduate thermodynamics course. There is considerable difference in opinion as to the best approach to the subject matter, and those faculty members who have been awaiting a "different" text will find this one to be disappointingly conventional. For example, there is much to be said for the development of a completely general mathematical statement of the First Law which is applicable to either open or closed systems as special cases, as opposed to the customary presentation of separate developments for each of these cases. While Smith and Van Ness take cognizance of this, the general development is given footnote

continued on page 10

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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959

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marginal notes

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status only and almost appears to be an afterthought.

Some criticism should perhaps be levelled at the repeated consideration of an ideal gas as a special case, although it cannot be said that non-ideality is not adequately treated. Somewhat more serious is the authors' intentional disregard for the sign convention with respect to heat flow (Q) when it suits them, for the reader may get the impression that he can do likewise without fully appreciating the consequences.

The book is remarkably free of errors and misleading statements, although the careful reader will find himself raising an eyebrow here and there. For example, the definition of fugacity is initially incomplete, and the oversight is not corrected until four chapters later. There is also a fascinating reference to pressure forces as illustrated on a "freeing body draw" of a cylinder!

DIRECTORY OF INDEPENDENT COMMERCIAL LABORATORIES PERFORMING RESEARCH AND DEVELOPMENT, National Science Foundation, U. S. Government Printing Office, Washington, D. C. (1957), vii plus 59 pp. 40 cents.

This is a valuable supplement to the information contained in *Industrial Research Laboratories of the United States* (1956), which lists industrial laboratories of all kinds including independent commercial laboratories.

PROGRESS REPORT ON SCIENCE PROGRAMS OF THE FEDERAL GOVERNMENT. Report of Committee on Government Operations, U. S. Senate, made by its subcommittee on reorganization and international organizations. U. S. Government Printing Office, Washington, D. C. (1958), v + 67 pp., 25 cents.

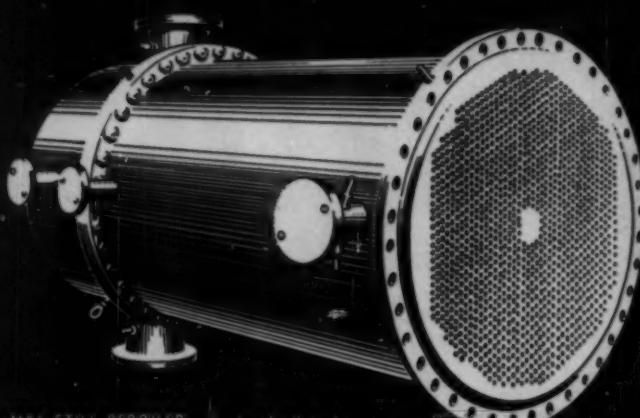
This is a summary of legislative and administrative actions taken to implement the provisions of the Science and Technology Act of 1958 (S. 3126) and related science programs.

REPORTS ON THE PROGRESS OF APPLIED CHEMISTRY, Volume XLI, 1956, Society of Chemical Industry, London, England (1958), 795 pp.

A survey of recent developments in the field of industrial chemistry, with citations to the literature where more detailed information can be obtained. Areas discussed include: fuel and fuel products; inorganic chemistry; metals; organic chemistry; biological products; textiles, plastics adhesives.

continued on page 12

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10 July 1959

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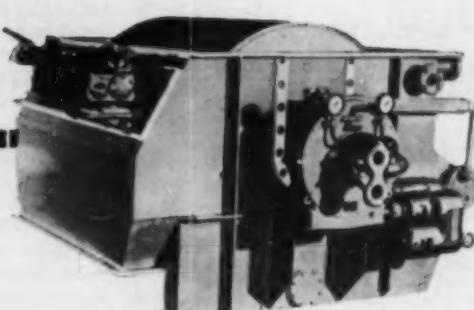
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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959

11



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marginal notes

from page 10

sives and paints; chemical engineering and hazards; agriculture and food.

TRANSFORM METHOD IN LINEAR SYSTEM ANALYSIS, John A. Aseltine, McGraw-Hill Book Co., New York, N.Y. (1958), 300 pp., \$8.50.

Throughout the book, special emphasis is placed on the ways in which the use of integral transformations can unify the methods of system analysis through the concept of the system function. The first half of the book deals with the Laplace transform and its application to problems in electricity and mechanics. This is followed by Fourier transforms and their application to problems involving noise. In conclusion, the Mellin transform is introduced as a method suitable for the solution of a class of variable-coefficient equations.

DIRECTORY AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC., 7th edition (1958), 100 pp.

A guide to the leading independent testing, research, and inspection laboratories of America.

The California Water Pollution Control Board has just published, as Publication No. 19, a 233-page booklet, "Investigation of Current Measurement in Estuarine and Coastal Waters."

This report presents the various aspects of current measurement in coastal and estuarine waters. The organization of the report consists of a classification and review of the various types of currents that occur in such waters, a classification of current detection methods, a discussion in detail of the instruments that have been developed, the methods and cost of data reduction, and conclusions and recommendations. The pertinent literature is cited in the list of references.

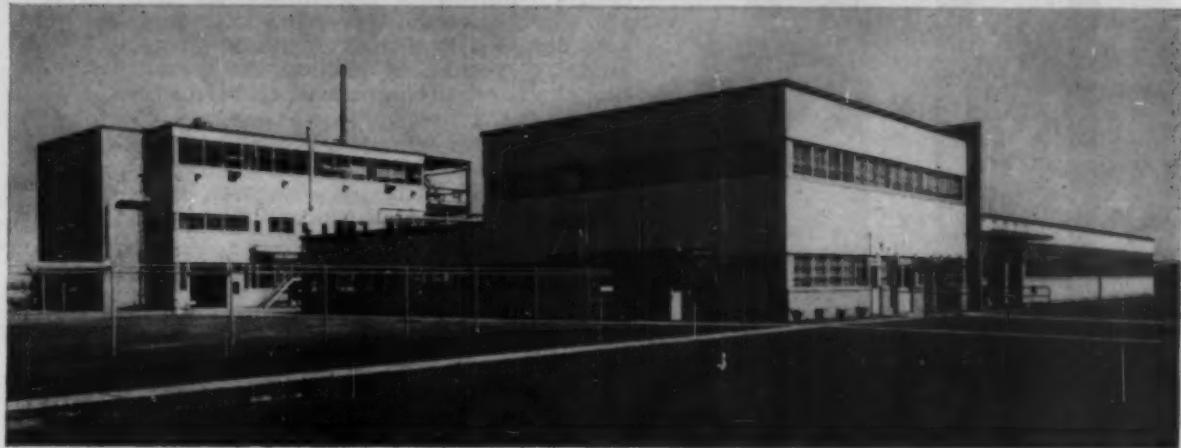
The report should be of considerable interest to chemical engineers interested in waste disposal in coastal waters, or in methods for measuring flow in large bodies of water.

Copies may be purchased from the State Printing Division, Documents Section, Sacramento 14, California, at a cost of \$1.75 per copy.

EFFECT OF SURFACE ON THE BEHAVIOR OF METALS. Lectures delivered at the Institution of Metallurgists Refresher Course, 1957. Published by Iliffe & Sons Ltd., London, and Philosophical Library, New York, 100 pp. \$10.00



Blaw-Knox builds complete Henry, Illinois, plant including all auxiliary facilities for B. F. Goodrich Chemical Company. Extensive tank farm includes raw material, finished product, and fuel storage. Main units shown below include process building (at left) office and warehouse units (at right).



B. F. Goodrich Chemical builds new \$5 million organic chemical plant

This new plant, built by Blaw-Knox, enables B. F. Goodrich Chemical to supply the oil, rubber, and plastics industries with a new series of antioxidants and other specialty chemicals.

In addition to the process areas on this complete-from-grass-roots project, Blaw-Knox's contribution included design, construction, and installation of the plant's auxiliary facilities. Utilities—including the water supply, waste disposal, and fire protection systems—were designed to handle about four times the plant's initial capacity. The tank farm with its extensive and complex piping system also was built to accommodate future increased output.

Throughout the entire project Blaw-Knox teamed closely with B. F. Goodrich to design a plant with a built-in future in meeting the increasing demand for rubber chemicals.

Contact Blaw-Knox Chemical Plants Division for a preliminary discussion on your next project. Headquarters in Pittsburgh; branch offices in New York; Haddon Heights, N.J.; Washington, D.C.; Birmingham; Chicago; and San Francisco.



plant builders for industry...

For more information, turn to Data Service card, circle No. 52

CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959 13

In the design of these MEA Absorbers and Strippers

INTALOX SADDLES

- Saved 20% in height
- 40% in gas pumping costs



The Gas Equipment Engineering Corporation of Mount Vernon, N. Y. designed and erected a 30 ton-per-day CO_2 generating plant. Two six foot diameter columns were used for absorbing carbon dioxide gas using MEA as the solvent. By using INTALOX Saddles for the tower packing, it was possible to reduce the tower height 20% below what would have been required with Raschig Rings. Not only was the capital cost greatly reduced but the columns performed even better than design requirements. Operating costs were also less because the appreciably lower pressure drop led to a 40% reduction in gas pumping expense. In addition, the greater-than-design scrubbing efficiency led to increased CO_2 recovery.

In mass transfer operations involving packed towers the use of Intalox Saddles almost invariably means increased capacities, lower pressure drops, and, of course, lower initial and operating costs.



U. S. STONEWARE

AKRON 9, OHIO

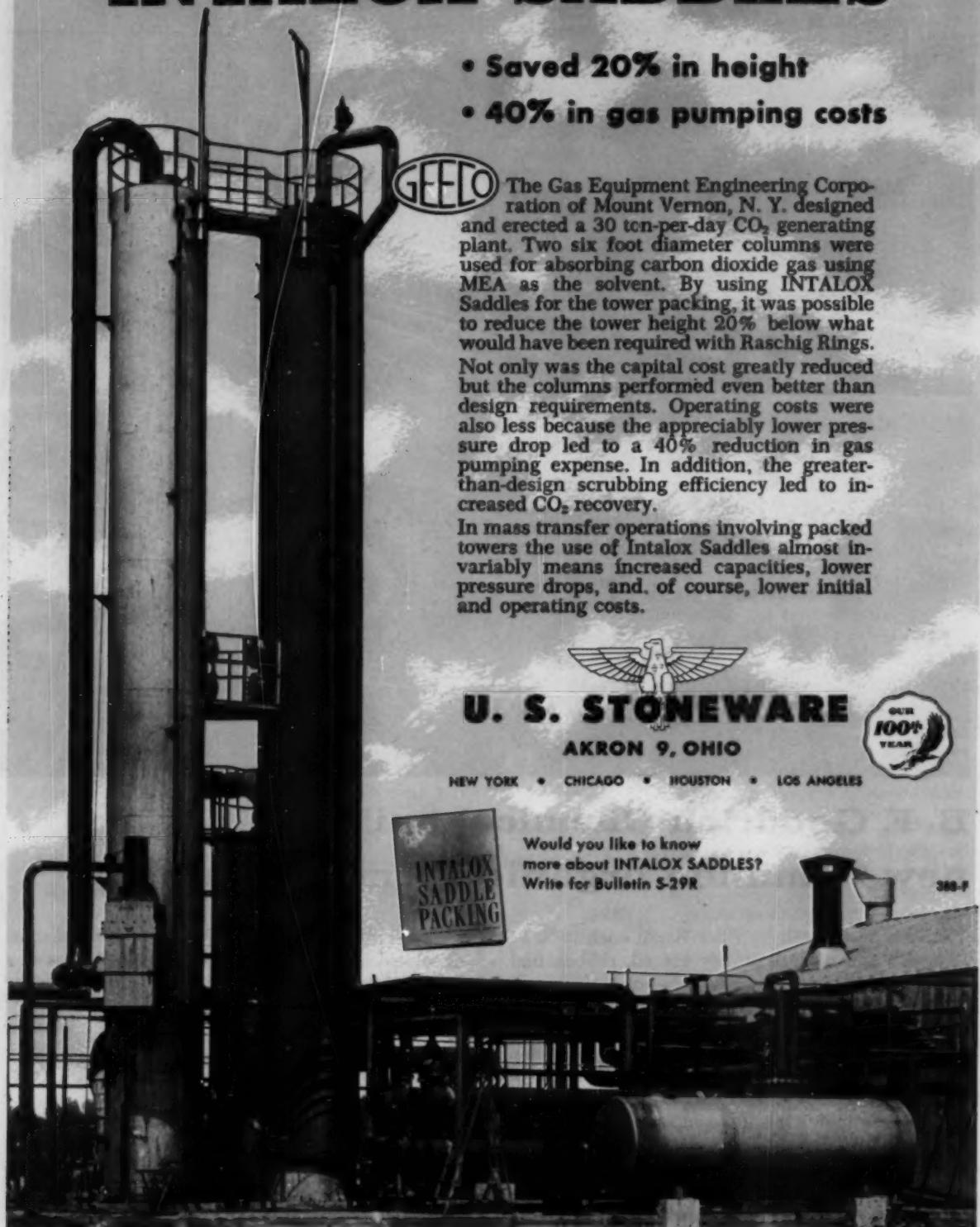


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Would you like to know
more about INTALOX SADDLES?
Write for Bulletin S-29R

388-F



For more information, turn to Data Service card, circle No. 54

German Plastics in Major Boom

In 1958, the German plastics industry achieved a volume of nearly 1.5 billion pounds, about 16 percent of the total world production, brought out Karl Mienes of Bad Godesberg (West Germany), speaking at a recent New York press conference under the sponsorship of Foster Grant Co. This represents a six-fold increase since 1950, compared to a mere 200 percent increase in total chemical production in Germany.

Of the total 1958 German production, continued Mienes, 60 percent was in synthetic thermoplastics and celluloses, 40 percent in thermosetting materials including epoxies, polyesters, polyurethanes, and silicones. Growth of the polyolefins, especially linear polyethylene and polypropylene, modified polystyrene, PVC polyblends, and polycarbonates, is expected to greatly influence the picture, starting in 1959. While, presently, two-thirds of the polyolefins consist of branched polyethylene, it is estimated that, by 1960, equal parts of linear and branched polyolefins will be produced. Greater polystyrene production is due primarily to high impact types, styrene-acrylonitrile copolymers, and foam polystyrene. Uses for acrylics are still increasing in Germany, said Mienes, but where toughness is required in addition to transparency, cellulose acetate-butylate is gaining in favor. An interesting application is the television picture screen, which is being injection molded in Germany. This particular outlet, however, could possibly switch to polycarbonate.

New polycarbonate

"Makrolon", the German polycarbonate, based on bisphenol and

reactive derivatives of carbon dioxide, is now in production. Its importance is said to be due to excellent form stability arising from its remarkably high transition point. Makrolon is also claimed to have unusual impact strength, and a sharply increasing tensile strength curve with small changes in elongation. It would seem particularly well suited for non-creeping structural parts.

Production of rigid PVC pipe, already in large supply in Germany, can be expected to shoot upward, said Mienes, following Farbwerke Hoechst's recent development of PVC-polyblends with chlorinated polyolefins. Pipe made from this material, he said, can be filled with water at 60-75 lb./sq. in. and frozen without bursting.

In another recent development Farbenfabriken Bayer has been able to eliminate unreacted di-isocyanate from polyurethane conversion products. This has permitted wide

use of polyurethanes in the lacquer industry in Germany. In the same field, propylene esters have been reacted with isocyanates, as in the U. S., to make materials of particularly high damping and shock absorbing properties for crash pads, etc.

Common Market is vital

Availability of basic raw materials in Germany, and other European countries, has not kept pace with this tremendous increase in production, pointed out Mienes, emphasizing that the recent French oil strikes in the Sahara are vital to the whole European petrochemical industry. The European Common Market, in his opinion, will greatly increase exchange of chemical processing know-how and of raw materials within Europe and, at the same time, far from being a barrier, will stimulate better cooperation with countries outside the Common Market, in particular the United States.

Personnel services for A.I.Ch.E. members

Now that A.I.Ch.E. is officially one of the five Founder Societies, any member is entitled to special lower rates for the good offices of the Engineering Societies Personnel Service. Advantages include a weekly bulletin listing engineering positions open in all parts of the U. S. For subscription rates and other information, address Engineering Societies Personnel Service: 8 West 40th St., New York 18; 84 East Randolph St., Chicago 1, Ill.; or 57 Post St., San Francisco 4, Calif.

New isotactic plastic

Montecatini, Milan, Italy, is now in pilot plant production of polybutene, made by directed polymerization of butene. It is claimed that polybutene films have been successfully laminated to paper, aluminum foil, and synthetic leathers. Potential uses are seen in sheets for vacuum and pressure forming, cable coverings, anti-corrosive coatings, liners for chemical reaction vessels.

Machine Translation—Miracle or Mirage?

Linguists are working with scientists from Omsk to Boston in a race to see who will first develop an electronic computer which can take over the job of translating technical literature from one language to another. Results to date (at least those which have been made public) are scanty, but enough scattered reports have come in to indicate that a breakthrough may be in the offing.

Efforts in the U. S. have logically enough been centered on Russian, for the good reason that only an estimated 2% of American scientists can read technical Russian, while a much greater percentage can handle French or German. One such project has been going on at Georgetown University where a more or less standard IBM 704 digital computer has been learning to be a translator. Most expensive part of the operation is said to be the labor involved in punching cards for the machine: this factor makes machine translation still far more costly than conventional translation practice. As for actual results at Georgetown, it is claimed that both Russian and French have been machine translated at a rate of about three words per minute, but that more speed is expected when an IBM 709 can be employed.

A somewhat more basic approach is being used at the Harvard Computation Laboratory in Cambridge, Mass. Here, computers are being used as "research tools" to improve the quality of machine translation, and to investigate the grammatical structure of the languages themselves, that is to say, "precise formulation of rules of grammar and syntax, and schemes for handling idioms." In a more direct practical application, workers at Har-

vard have already processed about 50,000 words of technical Russian on a "dictionary lookup" basis. This system, however, demands a considerable amount of skilled editing of the translated text after the machine has done its job, because any given Russian word may have several alternative meanings according to the context, and vice versa. The machine can print out all the possibilities: the job of the "post-editor" (human) is to choose those meanings which make the smoothest and most idiomatic finished translation.

In Russia, the center of machine translation research is said to be the Philology Department at the University of Leningrad. Going beyond mere machine translation, a Russian scientist has proposed the construction of an electronic "information machine" into which would be

fed "capsules" of all technical information published anywhere in the world. (Details of the machine are not available at the moment). Soviet researches in machine translation are said to include not only English and other European languages, but also such Asian languages as Indonesian and Burmese.

Some of the tangled threads of the problem may be knitted together at an upcoming international conference on machine translation to be held in Cleveland in September of this year, under the sponsorship of Western Reserve University and Rand Development Corp. Some 50 papers are already scheduled and more than 150 additional observers will be on hand. Participating countries are the U. S., Brazil, England, France, West Germany, India, Japan, The Netherlands, and the Soviet Union.

Washington Notes

Electrodialysis has been selected by the Office of Saline Water as the process to be used for the third saline water conversion plant. The proposed plant will convert brackish water at a rate of about 250,000 gal./day, will be located in the Northern Great Plains or in the Southwest. . . . Petroleum and chemical producers will be invited by the Bureau of Mines to a meeting for further discussion of the Government's proposed experiment with nuclear explosives in underground oil-shale deposits. . . . All bills to create a Department of Science and Technology have been killed by the Senate Operations Committee. . . . Eight new civilian power reactors have been authorized by presidential signature of Public Law 8650. Five will be built by the Government, and three by private industry with Government aid.

J. L. Gillman, Jr.

More than 200 proposals on U. S.—Euratom reactor program

Through May 15, 1959, over 200 proposals and letters of intent for participation in the joint United States-Euratom nuclear reactor research and development program have been received from U. S. and European firms, research groups, and educational institutions. Total amount involved in definite programs is said to be about \$37 million.

New directions for chemical engineering

Future of the profession to be surveyed by special A.I.Ch.E. Committee on Dynamic Objectives for Chemical Engineering. Council amplifies A.I.Ch.E. registration stand.

What needs to be done today and in the near future to enable our profession to make a maximum contribution to our society of tomorrow—this is the challenge which has been set by the Council of A.I.Ch.E. before a specially-appointed committee on Dynamic Objectives for Chemical Engineering.

Much has changed in the chemical engineering landscape since 1922 when a committee on chemical engineering education under the chairmanship of A. D. Little made a classic report to the Institute introducing the concept of Unit Operations. Today, there are new challenges. The Unit Operations are merging and disappearing in favor of more generalized concepts. Rather than concerning himself only with the components of a process, the chemical engineer, with the aid of machine computation, is making predictions on entire systems.

The study is intended to serve as a guide for educators, practicing engineers, and for the profession as a whole. The committee will also concern itself with the practical aspects of its recommendations by specifying in its report the areas in which work should be done, as well as the principles and basic concepts which need to be explored.

The Council has recognized, of course, that a committee small enough to be an effective working group cannot possibly represent all geographical regions of the country, all areas of interest, or all institutions and organizations involved in the question. For this reason, it has charged the committee to act as a forum or sounding board for the expression of views by all who wish to do so.

Council has set no fixed date for completion of the committee's report, but hopes that the work will be finished no later than December, 1960.

A.I.Ch.E. Registration stand amplified

In response to many requests from members of the A.I.Ch.E., Council has reaffirmed and amplified its previous statements on the position of the Institute regarding engineering registration. Here is the text of the amplified statement:

Individual registration

"Professional responsibility for engineering work is a personal responsibility and is based on adequate training, experience, intellectual capacity, and moral integrity. Registration is not a substitute for it. Because many of the factors which characterize a truly professional person cannot be measured quantitatively, the inherent personal nature of professional responsibility should be recognized in all laws relating to the registration and licensing of engineers.

"Although the A.I.Ch.E. does not believe that registration of itself contributes significantly to professional responsibility and professional development, it recognizes that in some cases, registration is considered to be one mark of public recognition of professional status. The A.I.Ch.E. takes the position that registration should be accorded no greater importance than is placed on other indications of pro-

fessional status, such as academic degrees, membership in professional organizations, technical publication, and advancement in industrial, academic, and governmental careers.

"The A.I.Ch.E. is not in favor of compulsory registration of all engineers. It recognizes, however, that all states have now enacted engineering registration laws, and it is possible that any engineer in the course of his career may wish to become engaged in activities requiring registration. Therefore, the A.I.Ch.E. recommends that its members should, as a practical expedient, become registered in their respective states as soon as possible after entering the profession.

Form of business organization

"Believing that individual professional responsibility is the only adequate safeguard of the public interest, and that the size and nature of an engineering organization is not a criterion of such professional responsibility, the A.I.Ch.E. feels that there should be no discrimination by implication, omission, or direction as to the form of business organization (individual, partnership, corporation, or other) through which the professional services of engineers can properly be offered. Laws regulating the public practice of engineering, while they may require the registration of the engineer or engineers in responsible charge of a project, should not require the *ex-officio* registration of corporate officers, directors, or others.

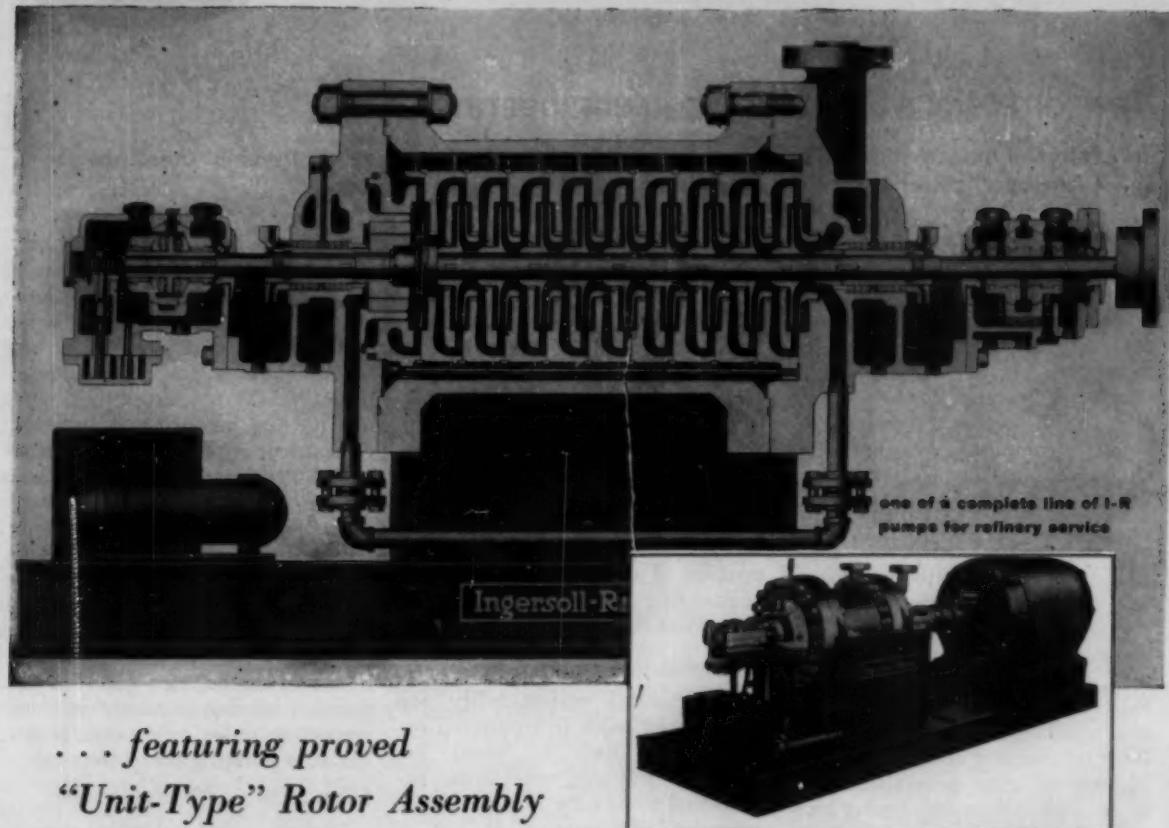
Thiokol-Marquardt merger off

Negotiations looking toward the merger of Thiokol Chemical and Marquardt Corp. have been discontinued "by mutual agreement."

NEW

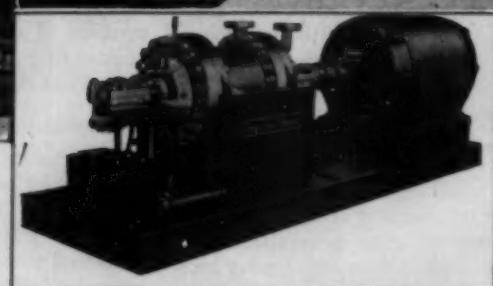
INGERSOLL-RAND[®] CHARGE PUMPS

Offer Longer Life on High-Pressure Process Service



... featuring proved "Unit-Type" Rotor Assembly

The new Ingersoll-Rand CMR pump is specifically designed for high-pressure process service, where operation without a spare requires top performance and exceptional dependability. It is a horizontal, multi-stage unit with vertically-split barrel-type casing, suitable for a wide range of low-capacity, high head applications in refineries or other process plants.



Available in 1½ and 2½ inch discharge sizes, the CMR pump will efficiently handle capacities up to 400 gpm, pressures to 1500 psi and temperatures to 750°F.

Some of the outstanding features are noted below. For complete information, contact your Ingersoll-Rand representative.

FEATURES:

- **High-Strength Casing** ... The main barrel is made from centrifugally-cast steel with forged steel ASA flanges welded at both ends. The nozzle head and discharge head are one-piece carbon steel castings which bolt to the casing flanges. The main casing joints are sealed with confined flexitallic gaskets. The pump can be dismantled without disturbing the piping connections.
- **"Unit-Type" Rotor Assembly** consists of separate channel ring segments, impellers and shaft. It can be easily removed from the pump as a unit to facilitate maintenance.
- **Impellers and Wearing Rings** ... The single-suction, closed type impellers are cast in one piece and mechanically balanced to assure smooth, vibration-free operation. Casing rings, pressed into the channel rings, and locked against rotation, are easily renewed to maintain close running clearances.

- **Hydraulic Balance** ... Multiple-volute diffuser construction completely eliminates radial thrust. A balancing drum effectively counteracts axial thrust due to pressure differentials across each stage. Residual thrust is taken up by the thrust bearing.
- **Bearings** ... Spherically seated, self-aligning Kingsbury thrust bearing and sleeve-type radial bearings are pressure lubricated by a gear oil pump driven from the outboard end of the shaft. An oil reservoir and shell and tube-type cooler are mounted on the pump base.

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U.S.I. CHEMICAL NEWS

July

A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries

1959

New Managerial Positions Created in U.S.I. Sales



W. E. JOHNSON

Warren E. Johnson, Vincent D. McCarthy and George H. Stanton have been named to fill three new sales management positions which have just been created by U.S.I.

Mr. Johnson, who is appointed Director of Chemical Sales, will

have responsibility for Industrial Alcohol and Solvents, Heavy Chemicals, Sodium and Special Products Sales, with the manager of each product group reporting to him. Mr. McCarthy as Director of Plastics Sales, will have responsibility for management of polyethylene sales, as well as other plastic materials that the company might produce in the future. Mr. Stanton, who will assume the position of Director of Field Sales later in the year, will supervise the activities of regional sales offices. The three new appointees will report to Alden R. Ludlow, Jr., Vice President in Charge of Sales.

"We are confident these important changes will considerably strengthen our sales organization," Mr. Ludlow says, "and enable us to keep pace with our increasing business."



G. H. STANTON

The new Director of Chemical Sales, Warren Johnson, has been Manager of Alcohol and Chemical Sales for U.S.I. Vincent McCarthy, Director of Plastics Sales, has been Manager of PETROTHENE® Polyethylene Sales. And George Stanton, Director of Field Sales, has been Manager of the U.S.I. Chicago Sales Division.

All-Titanium Centrifugal Pumps and Valves Are Now Being Produced

Centrifugal pumps and valves made of commercially pure titanium have been developed to meet the ever increasing need for more corrosion resistant equipment in the chemical industry. Made to order, pumps are available in sizes from 1" x 1" and capacities from 1/2 gpm. Valves are available in a size range of 1" through 4", and nonlubricated and non-sticking plug valves are also available in sizes of 3/4" through 3".

This equipment, designed in titanium specifically for the highly corrosive environments found in chemical plants, is said to be very competitive pricewise with similar units fabricated from nickel-base alloys. The titanium used is a product of Mallory-Sharon Metals, owned one-third by U.S.I.

1958 Aerosol Survey Results Are In; Production of Nonfood Units Estimated at 20% Above 1957

Hair Sprays Still Sales Leader; Dental Cream, Pet Product Sales Large Enough for Separate Statistical Categories.

At the Chicago meeting of the Chemical Specialties Manufacturers' Association this May, it was announced that an estimated 470 million nonfood aerosol units were produced in the U.S. in 1958, with an approximate value of \$470 million.

Researchers Uncover More Uses of Methionine in Body

Recent work with radioisotopes by the Biology and Medicinal Division of the Argonne National Laboratory has revealed that methionine in the body, when converted to adenosylmethionine, can participate in epinephrine synthesis; react with niacin; enter the brain; and help form spermine, ergosterol and histamine.



V. McCARTHY

New Ultraviolet Absorber Developed for Polyethylene

A new compound now in the process development stage has recently been made available to polyethylene manufacturers for evaluation as an ultraviolet absorber. The material — 2,2'-dihydroxy-2-n-octoxybenzophenone — is compatible with polyethylene because of the long n-octyl chain, and it is said to absorb strongly in the 300-375 millimicron UV range.

In field tests made by the producer with 10-mil polyethylene film, it was found that incorporation of 0.171% by weight of the absorber was adequate to retain 85% elongation after two months' use in an area of strong sunlight.

Currently, carbon black is the only effective UV absorber compatible with polyethylene and used to protect the plastic in outdoor service. The new compound is a pale yellow powder and, if proven successful in practical application, will permit the outdoor use of clear and colored polyethylene goods.

New System Developed For Extruding Metallic Sodium in Wire Form

For many reactions, where small amounts of sodium in wire form are required, there has long been a need for equipment capable of producing wire from the standard one-pound cylindrical sodium brick, with minimum loss and effort.

MORE

NONFOOD AEROSOLS REPORTED IN 1958 COMPARED TO 1957		
	(figures in millions of units)	
Product	1958	1957
Hair Sprays	92.6	94.4
Room Deodorants	49.8	42.0
Shaving Lathers	45.3	50.9
Insect Sprays	42.3	41.5
Coatings	30.1	36.5
Colognes & Perfumes	13.6	17.9
Dental Creams	12.9	•
Household Products Other Than Room Deodorants	25.9	28.1
Personal Products Other Than Hair Sprays, Shaves, Dental Creams, Colognes & Perfumes	14.5	12.4
Nonspecific	14.4	15.6
TOTALS	341.4	339.3

* not reported separately in 1957

July

★

U.S.I. CHEMICAL NEWS

1959

CONTINUED

Aerosols

units. Again, the reported figure is believed to be substantially less than the number of units actually produced. Veterinarian and Pet Products, the other new category on the questionnaire, showed a reported figure of 3 million units. Serious consideration was given by the CSMA committee to the inclusion of food products in the 1958 survey. However, after careful weighing of the various factors involved, it was decided to postpone inclusion until 1959.

U.S.I. Products Used in Aerosols

Two U.S.I. products, ethyl alcohol and polyethylene, have played an important role in the steady growth of the aerosol industry. Anhydrous ethyl alcohol is virtually a universal ingredient in hair sprays, room deodorants, perfumes and colognes, and is widely used in other personal products and in pharmaceuticals now sold in aerosol form. Polyethylene is an important component in packaging, being used for dip tubes and valve parts. U.S.I. provides nationwide distribution of these products, and technical assistance on their use.

Aerosol industry leaders predict a continued rise in the sales curve. One of the largest makers of containers forecast recently that total production of aerosols should reach 555 million units this year.

Ethyl Alcohol Permits Two-Color Dyeing Effects On Cotton-Acetate Fabrics

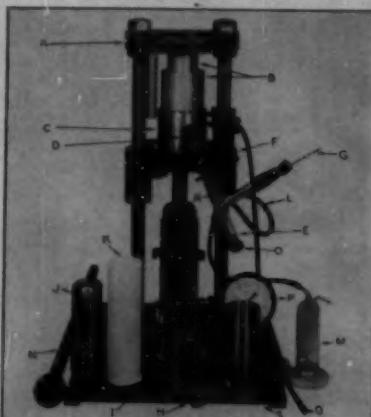
It is reported that in the vat dyeing of cotton-acetate fabrics, ethyl alcohol has been employed to achieve two-color effects by differential swelling of fibers. The fabric is treated at 40°C in a weak alkaline solution containing vat color and 70% ethanol in equal parts.

The acetate fibers are said to take the dye strongly, while the cotton fibers remain practically undyed. Cross-dyed effects can be achieved by dyeing the cotton in a subsequent bath without ethanol. The ethyl alcohol acts by swelling the acetate fibers and depressing any swelling of cotton.

CONTINUED

Sodium Wire

Researchers at the U.S.I. laboratories in Cincinnati have recently developed such a system, which is described completely in a technical data sheet now available. A photograph of the system, with descriptive legend, appears below. Any laboratory press capable of delivering 10-15,000 psi is suitable.



System for extruding sodium wire: (A) press; (B) body & plunger, $2\frac{1}{4}$ " mold; (C) die assembly; (D) die plate holder & adapter; (E) adapter for cutting sodium wire; (F) clamp; (G) sodium wire cutter; (H) cutter for cleaning oxide layer from feed stock; (I) & (J) bar & knockout rod for pushing plunger from mold body; (K) sodium feed stock; (L) tube for inert gas blanket; (M) bubbler indicating inert gas flow; (N) press oil-pump handle; (O) stopper (when tube not in use); (P) pressure gauge; (Q) inert gas inlet tube; (R) sodium wire.

Sodium wire extruded in this equipment can be used, as an example, for a standard Bouveault-Blanc reduction of diethyl sebacate to decamethylene glycol. In this reaction, carried out with sodium in a considerable excess of absolute ethanol at 85-95°C, the sodium must be added slowly because of its great reactivity with ethanol at the temperatures required. The extruded wire form is ideal for the purpose. Procedure for this reduction is described in detail in the U.S.I. technical data sheet entitled: "Laboratory Production and Use of Sodium Wire," which is obtainable upon request.

PRODUCTS OF U.S.I.

Alcohols: Ethyl (pure and all specially denatured formulas); Anhydrous and Regular Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL® M, ANSOL® PE.

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fatty Oils, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoxycinnamide, Acetoacetyl-Ortho-Chloranilide, Acetoacetyl-Ortho-Tetralide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P.

Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Intermediates.

Heavy Chemicals: Anhydrous Ammonia, Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Soda, Chlorine, Metallic Sodium, Sodium Peroxide.

PETROTHENE® Polystyrene Resins

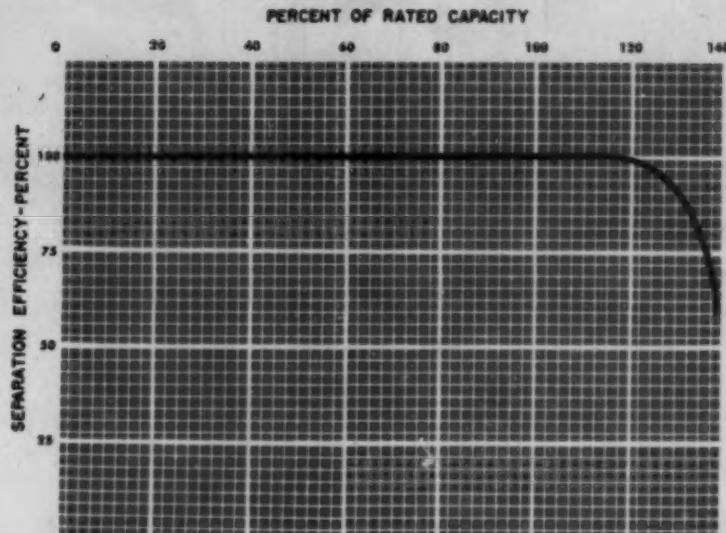
Animal Food Products: Antibiotic Feed Supplements, Calcium Pentahydrate, Choline Chloride, Special Liquid CURBAY, Mandelins (Vitamin K₃), DL-Methionine, MOREA® Premix, Riboflavin Products, U.S.I. Formulary, Vitamin B₁₂ Feed Supplements, Vitamin D₃.

U.S.I. SALES OFFICES

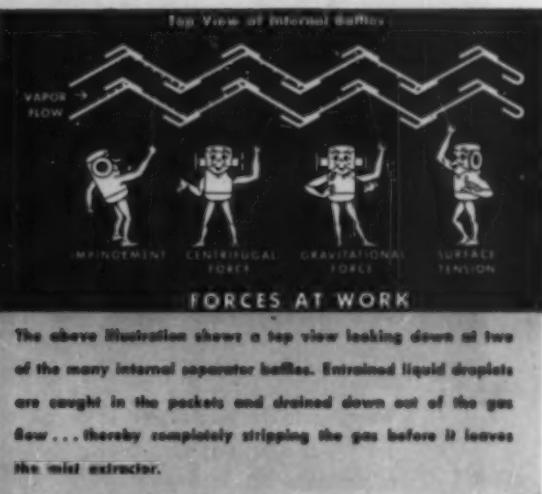
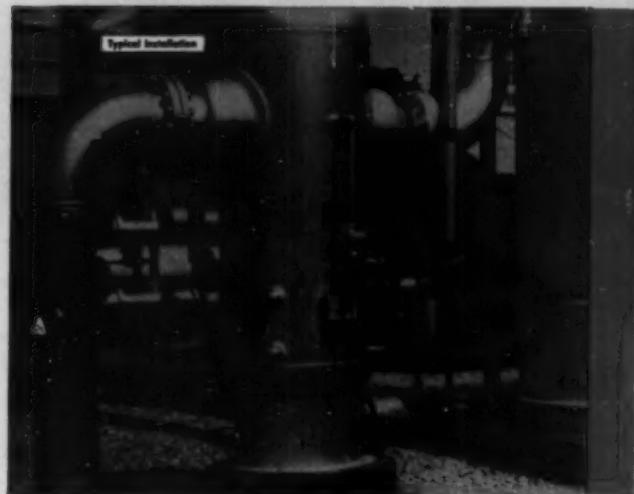
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you can remove entrained
liquids from process vapor
lines and maintain a
high efficiency over the
entire range of flow.



The above illustration shows a top view looking down at two of the many internal separator baffles. Entrained liquid droplets are caught in the pockets and drained down out of the gas flow . . . thereby completely stripping the gas before it leaves the mist extractor.



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- Low pressure drop across mist extractor — less than 6" of water.
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- Mist extractor and vessel can be made of any type material. Carbon steel mist extractors can be placed in a vessel and stress relieved without damage.
- Can be designed for any capacity or special requirement.

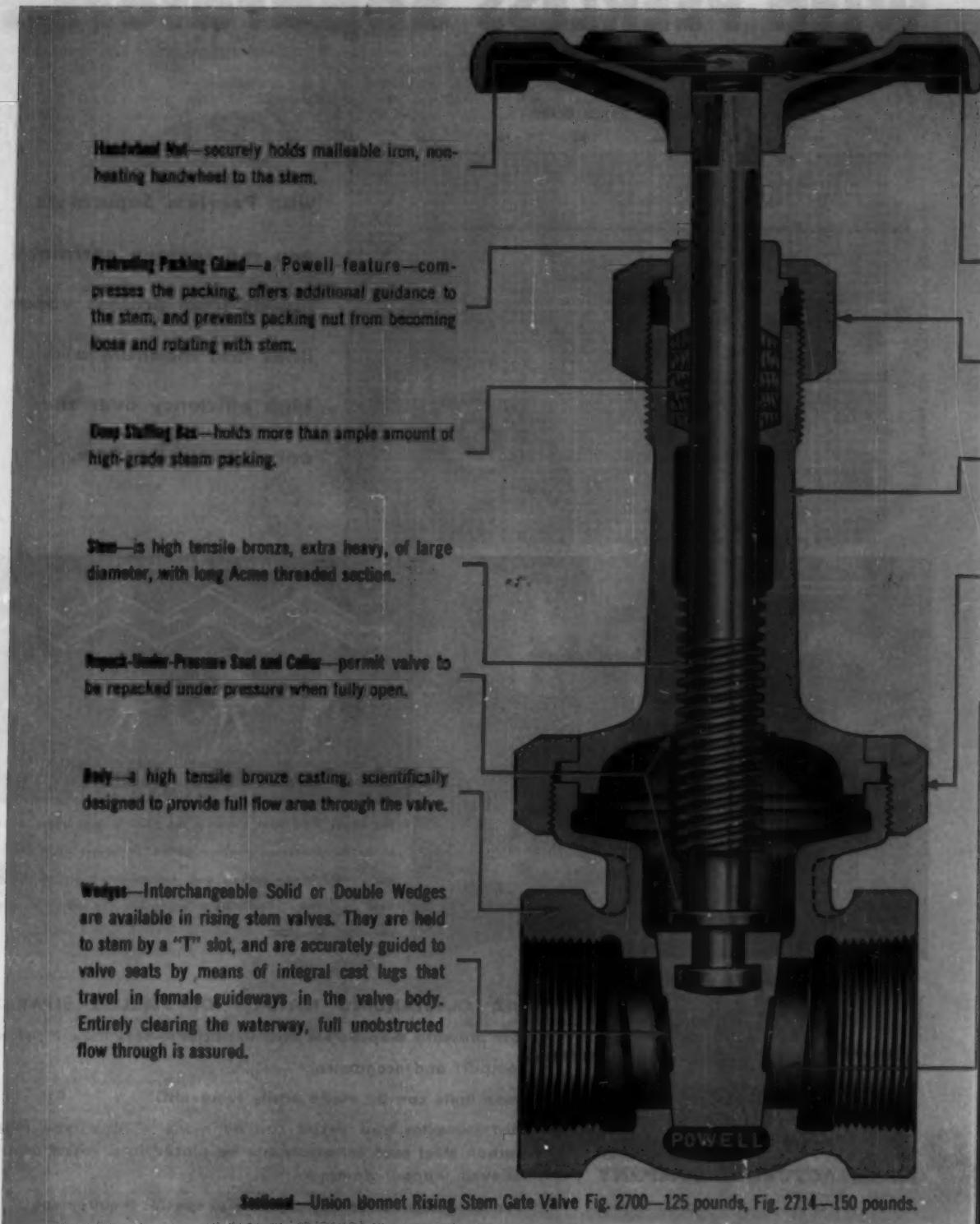
OVER 20,000 SEPARATORS and SCRUBBERS IN SERVICE

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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959 21

ANNOUNCING NEW **POWELL**



Handle Nut—securely holds malleable iron, non-heating handwheel to the stem.

Pressing Packing Gland—a Powell feature—compresses the packing, offers additional guidance to the stem, and prevents packing nut from becoming loose and rotating with stem.

Deep Shifting Box—holds more than ample amount of high-grade stem packing.

Stem—is high tensile bronze, extra heavy, of large diameter, with long Acme threaded section.

Repack-Under-Pressure Seat and Collar—permit valve to be repacked under pressure when fully open.

Body—a high tensile bronze casting, scientifically designed to provide full flow area through the valve.

Wedges—Interchangeable Solid or Double Wedges are available in rising stem valves. They are held to stem by a "T" slot, and are accurately guided to valve seats by means of integral cast lugs that travel in female guideways in the valve body. Entirely clearing the waterway, full unobstructed flow through is assured.

Sectioned—Union Bonnet Rising Stem Gate Valve Fig. 2700—125 pounds, Fig. 2714—150 pounds.

POWELL... world's largest family of valves

BRONZE UNION BONNET GATE VALVES

for 125 and 150 pounds WSP

These new BRONZE Union Bonnet Gate Valves have many superior features—some of which are outlined here. For complete details, write for new illustrated circular. Or check with your nearest Powell Valve distributor.

Identification Plate—gives Figure Number and kind of valve.

Heavy Hexagonal Packing Nut—for holding gland and adjusting packing.

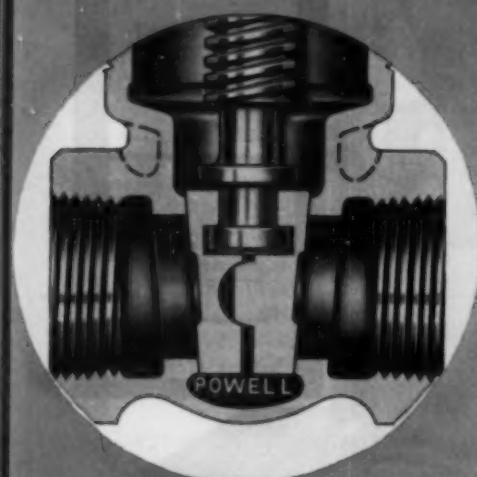
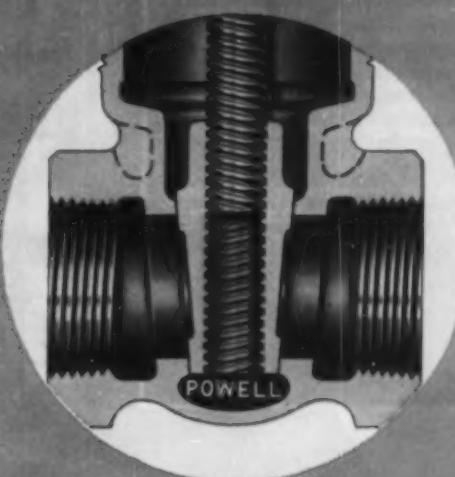
Long Bonnet—cast of high tensile bronze for long service.

Double Ring Nut—is deep threaded and tightly holds body-bonnet connection. Affords additional wrenching positions.

Angle Spac—between seats and end of pipe thread prevents injury to seats when screwing pipe into the body.



Fig. 2707—125-pound Union Bonnet Non-Rising Stem Gate Valve. Also available for 150 pounds—Fig. 2712.



Detail of Sectional View Inside Screw Rising Stem Gate Valve showing Double Wedge Disc and Integral Seats.

Detail of Sectional View Non-Rising Stem Gate Valve showing Solid Wedge Disc that rises on stem. Integral Seats.

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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959 23

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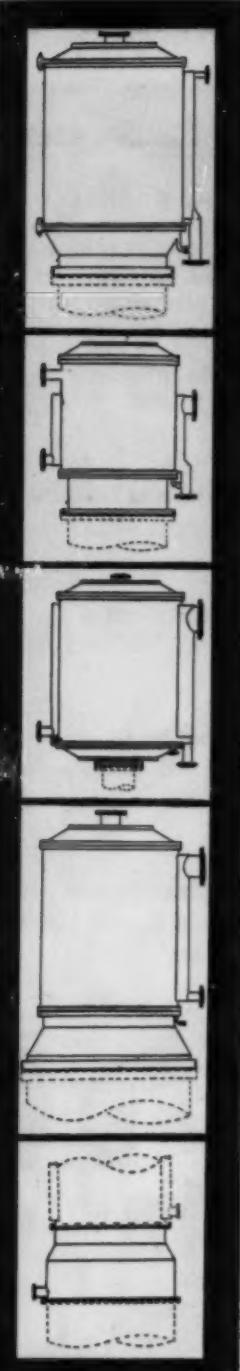
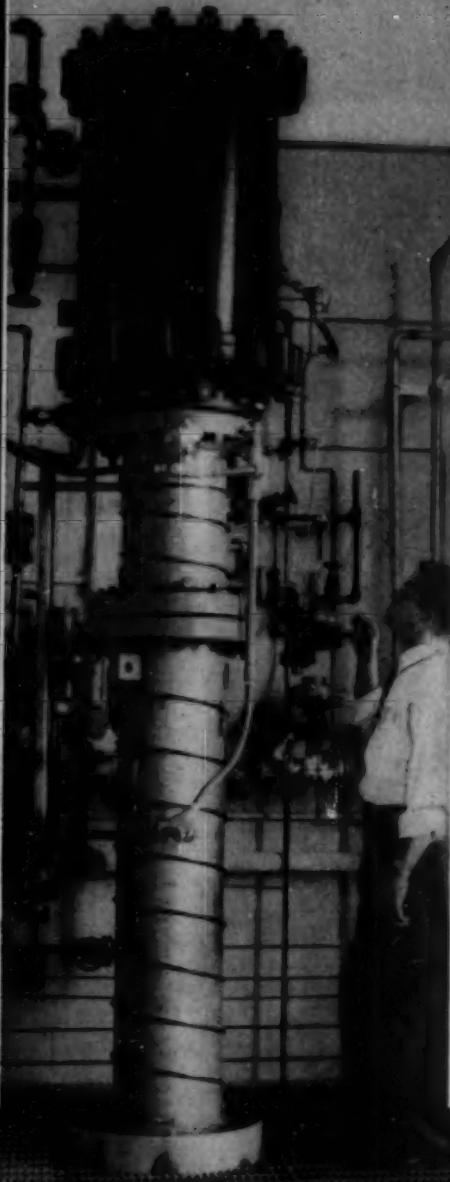
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*Teflon is DuPont's trademark for TFE fluorocarbon resins.

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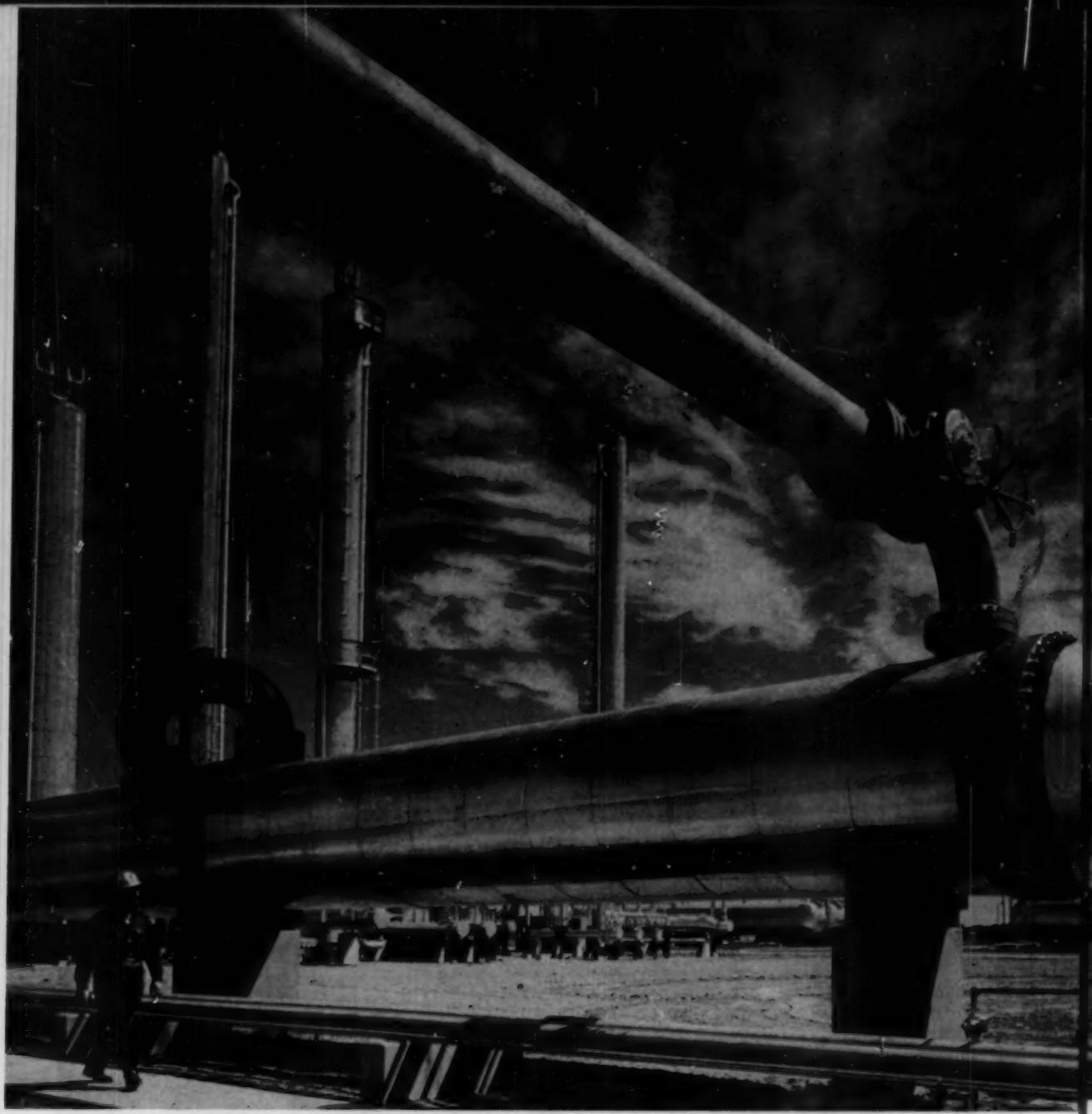
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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959 25



The extraction plant of Runnels Gas Products Corporation at Eunice, La., processes more than 300 mmcf. of pipeline gas daily to yield 5,000 barrels of liquid hydrocarbons (all the natural gasoline and butanes, 96% of the propane and 35% of the ethane.) Fuel-gas consumption is less than 3%. Absorption takes place at -40°F.

What's new in gas processing?

Anyone contemplating construction of a natural-gas processing plant, whether its purpose is treating, extraction or a combination of both, must first solve a puzzle with three complex variables. The efficiency and profitability of the plant depend on how well the puzzle is solved.

The first variable is, of course, the volume and composition of the inlet gas stream. The second is the market, if any, for extracted products, and the third is the legal and technical requirements for residue gas.

Major shifts in these variables make it profitable today to design gas-processing plants that differ radically from those built only a few years ago, and to locate them much farther away from the gas fields.



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For example, it is now advantageous to build large, highly efficient extraction plants to handle great volumes of lean Louisiana gas. Such plants serve the tremendously expanded LPG market for butanes and propane, and the petrochemical market for both of these, plus ethane. Because of the volume of gas, and the degree of extraction desired, a combination of extreme cold and light-oil absorption is the most efficient way to get the marketable hydrocarbons out. Refrigeration costs are more than offset by the use of smaller quantities of lighter oil, with consequent savings in pumping and stripping capacity.

As the natural-gas industry mushrooms, the trend is toward large plants, not only for hydrocarbon extraction but for sour-gas treating as well. And as the plants

grow bigger, new levels of efficiency can be reached through methods that were impractical in smaller installations.

The development of new techniques for large-volume gas processing has been a Fluor contribution to the industry. The combined experience of the gas specialists in Fluor's Los Angeles and Midcontinent divisions represents a pool of advanced know-how that is unequaled anywhere.

The Fluor brochure, "Opportunities in Gas Processing," will be helpful to anyone planning construction of a processing facility. Write to Dept. 41, The Fluor Corporation, Ltd., 2500 South Atlantic Boulevard, Los Angeles 22, California.

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about our authors

W. T. Purvance was works engineer for Columbia Geneva Steel's Geneva plant near Provo, Utah, when the studies were made on which *Atmospheric Pollution Control* is based. During Purvance's tenure as works engineer, Geneva received world wide recognition for successfully prefabricating an open hearth furnace outside the open hearth shop and moving it into place as a complete unit. Purvance, who began his employment with U.S. Steel in 1942, directed the activities of Geneva's Engineering Department, which includes 120 engineers, draftsmen and other employees. He just recently transferred to the U.S. Steel Pittsburgh plant as project analysis engineer.

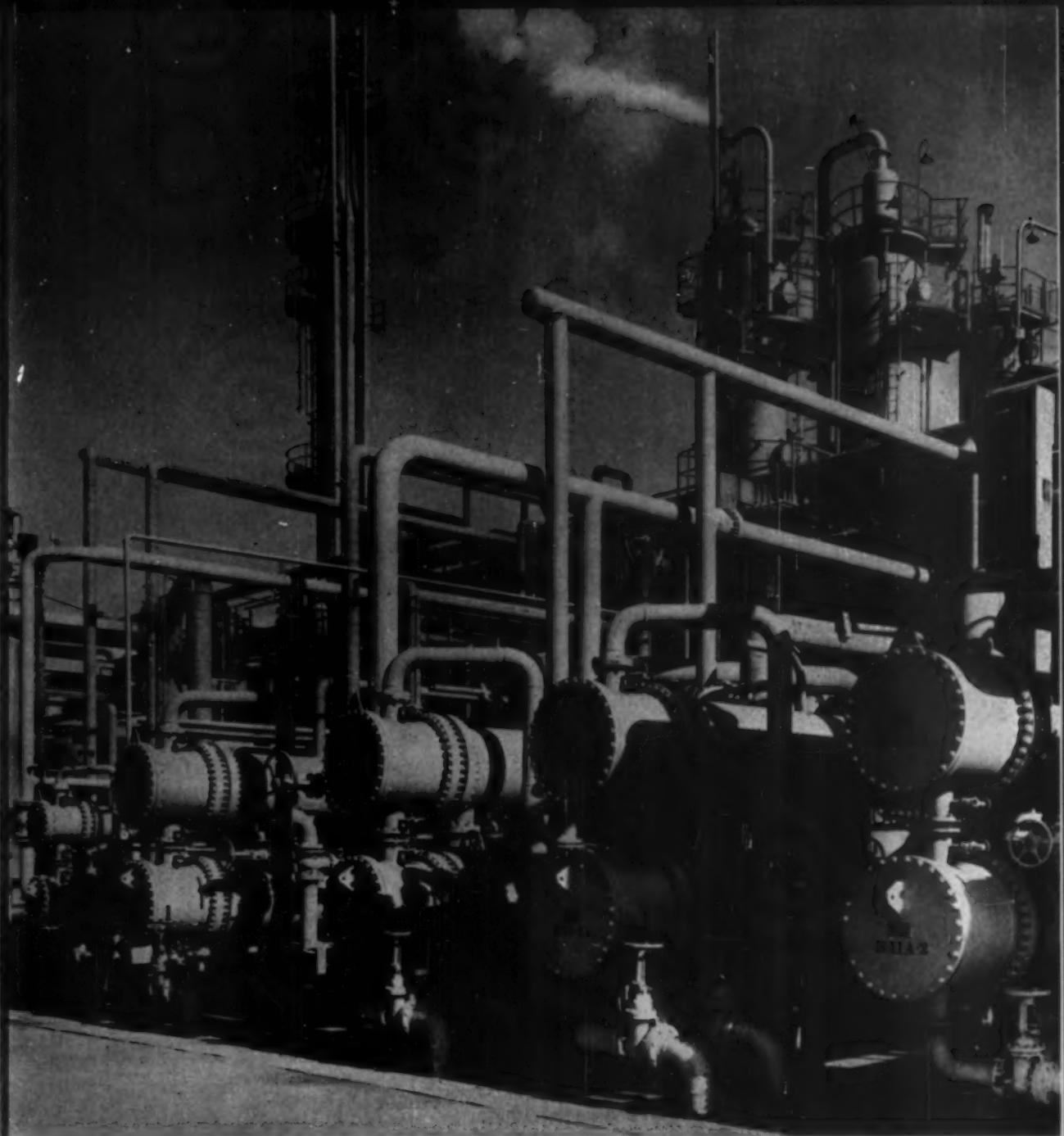


Authors Purvance (left) and Knauff.

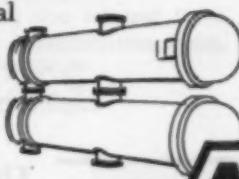
The European chemical industry, says Hans W. Knauff (*International Licensing*), realizes, after two world wars and many changes, that new technical developments cannot be monopolized. The decision to grant or take a license is now one of time rather than principle, and centers on economic appraisal. Knauff, an industrial chemist, joined I. G. Farbenindustrie, A. G. Leverkusen, Germany, in 1934, and was employed in the patent department for a number of years. He has been with them ever since, in various capacities, all adding to his knowledge of the field in which he makes his contribution to *CEP* this month. Knauff was head of the patent department, took over special projects in foreign operations in 1953, and a year later was appointed director of Farbenfabriken Bayer in charge of licensing and other projects in foreign countries.

John J. McKetta, L. Leibson, and E. M. Jones are all leaders in the work of the Institute. The survey (*What's the A.I.Ch.E. Doing for You?*) which appears in *CEP* this month grew out of their interest in the membership campaign. McKetta, who is with the Chemical Engineering Department at the University of Texas in Austin, Texas, is a national director of the organization. He is a *continued on page 30*

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about our authors

from page 28

sultant at Gulf Publishing, and a former editor of *Petroleum Refiner*. Jones is with Monsanto Chemical at Texas City, Texas. He was vice chairman of the national membership committee under McKetta, and succeeded him to chairmanship. Leibson works with Humble Oil & Refinery at Baytown, Texas, and is vice chairman in charge of the southern district membership committee.

R. Parkins (*Continuous Distillation*) is head of the chemical engineering section in the General Chemicals Division of Imperial Chemical Industries, Ltd., in Liverpool, Eng. He is a graduate of London University in Chemistry and Mechanical Engineering.

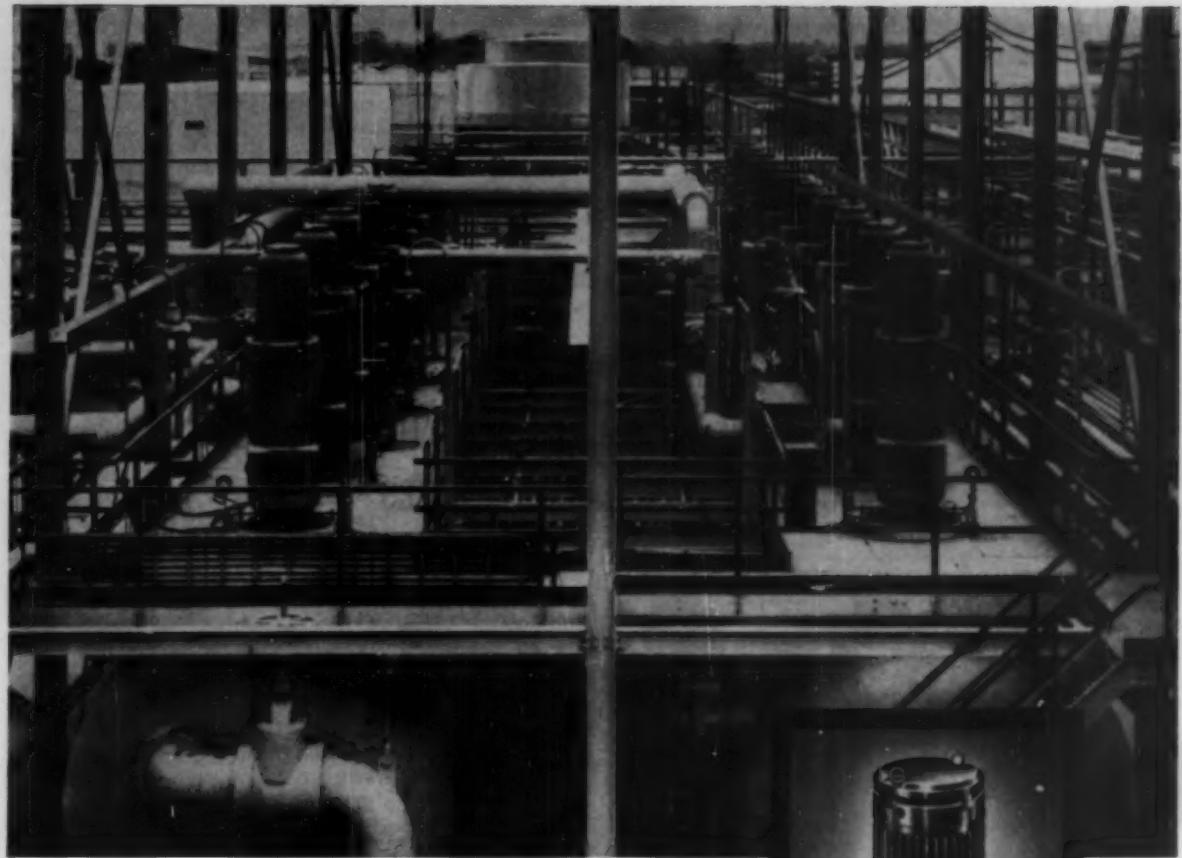


Authors Parkins (left) and Segal.

Donald Q. Kern (*Optimum Trim Cooler Temperature*) is an old friend of CEP, having made many contributions to its pages. His latest representation was last month with an article on *Surface Fouling*. Kern, who now heads his own organization in Cleveland, also lectures at Case Institute of Technology.

K. D. Segal (*Economics of Air Fin Coolers*) has been actively associated with the application of air fins to the oil refinery industry at Esso Research and Engineering. He was introduced to the problem of refinery heat exchangers when he worked at the Aruba Refinery of Lago Oil and Transport.

Just off the press is the new A.I.Ch.E. Directory. A complete guide to the membership of the Institute, it contains an alphabetical list of members, revised to January 15 of this year. A break-down by states, as well as a section on foreign members, is included. The 165-page booklet is a source of indispensable information on the organization of A.I.Ch.E. itself, with a listing of national and local section officers, committee members, the constitution and by-laws, and organization history all included. Write for copies to: A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.



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July 1959 31

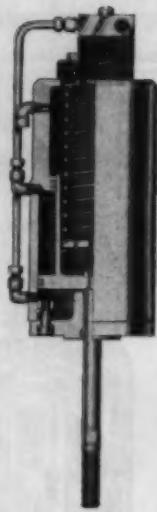
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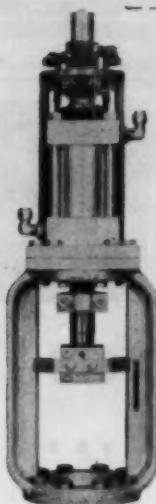
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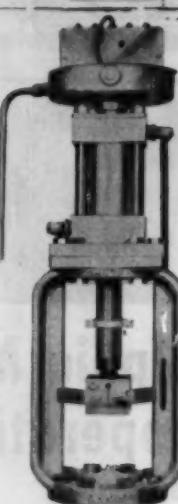
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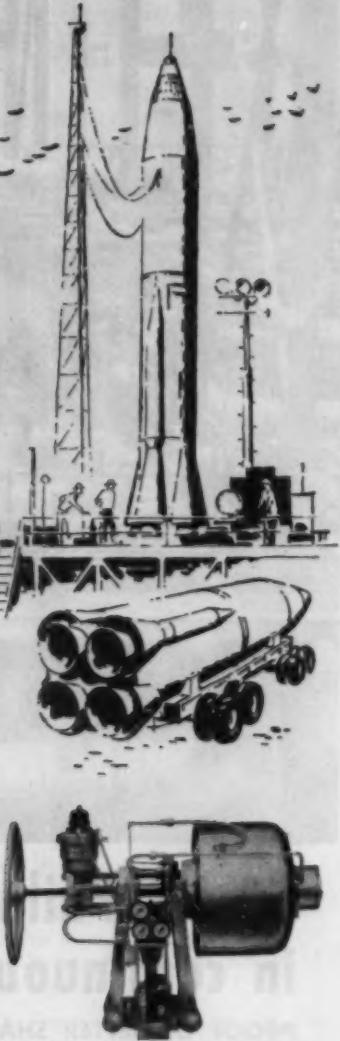
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New products, new markets

Among the new products to tempt the chemical industry into further plant expansion is polypropylene. One of the little talked about outlets for this new material is in the field of textiles. Only a short time ago, polypropylene fibers were looked upon as presenting serious problems. Now it has been announced that promising results have been achieved in the laboratory which overcome tendencies for the fiber to fade and become brittle in sunlight. Also, polypropylene now appears to be nearing the stage where it can be dyed in fiber form by conventional textile means. Fine denier yarns are likewise in the making—all of which adds up to the likelihood that a new major synthetic fiber is in the making. In the meantime, Montecatini is building a plant in Italy which is said to have an output of 10 million pounds of staple polypropylene fiber and filament a year.

Not to be overlooked in the fibers field is the evolutionary development taking place within Dupont of both nylon and Dacron. Through this work, fibers and filaments of end-use properties closely keyed to final product needs are said to be forthcoming.

From the *Chemical Economics Newsletter** come gleanings about several commodities of importance to the process industries. Natural gas, for example, which accounted for only about 10 percent of the acetylene produced during 1953-56, has risen to approximately 15-20 percent of the total acetylene production by 1958. However, the CEN predicts that natural gas will probably not become the major source of this vital raw material in the next five to ten years because of the likelihood of continued increases of natural gas prices, and because the investment required for natural gas acetylene is approximately twice that for calcium carbide acetylene.

Caustic potash, according to the CEN, is likely to experience a rising market demand because of liquid heavy duty detergents, which are anticipated to increase in market popularity. The liquid formula-

tions will probably call for potassium phosphates—with the granular detergents using sodium phosphates.

Detergents are likewise responsible to a considerable degree for the growth of demand for sodium carboxymethylcellulose (CMC), according to the CEN. The imported natural water soluble gums, such as gum arabic and locust bean gum have been displaced to a degree. From 1949 to 1956, total imports of these gums ranged from an initial low of 32.2 million lbs./yr., to a final high of 41.7; then falling off to 34.5 in 1957. In the same span (1947-57) CMC domestic production has grown at an average rate of 45 percent/yr. Production of CMC in 1957 was 32.2 million lbs.—only slightly lower than the total imports of water soluble gums (34.5). In 1955, 37 percent of the total domestic production of CMC was used as a promoter in detergents.

The penetration of fertilizer-grade ammonium nitrate into the explosives field is graphically illustrated by CEN's estimate that the 1958 demand for explosive oil (nitroglycerin, nitropolyglycerin, nitrocellulose, ethylene glycol dinitrate) was 15 percent lower than in 1957. The ammonium nitrate requires mixing only with fuel oil on the blasting site—producing an explosive having the same powder factor (ratio of lbs. blasting agent to cu. yds. of earth) as 60 percent gelatin dynamite at about half the cost.

How such trends affect company operations is indicated by CEN by the following example: In July, 1957, Atlas powder launched a \$4 million modernization program to take place over a period of 9 months at its Missouri explosives plant. Included was to be a unit for continuous conversion of nitric acid to nitrate by the new Stengel process. Then, in September 1958, Atlas announced closing of its nitroglycerin explosives plant in White Haven, Pa. Coincidentally with the closing of the Atlas plant was the completion by American Cyanamid of a new ammonium nitrate plant at New Castle, Pa., which is said to increase that company's explosive capacity by 60 percent.

* Permission to quote has been granted by Stanford Research Institute.

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opinion and comment

One year later

Just one year before the time that this editorial is being written, A.I.Ch.E. celebrated its Fiftieth Anniversary. Since the members were reminded for months of the accomplishments commemorated by that event, they will doubtless welcome the change of looking into the rear-view mirror at what has passed since that milestone. Here are just a few of the high spots.

The Program Committee began holding one-day highly technical programs in specific fields—the first of these being special lectures on turbulence given in December of last year. Earlier the Institute managed a three-day Heat Transfer Conference in Chicago in cooperation with A.S.M.E., and along with the Federation for Instrumentation, Education, and Research, the Institute is sponsoring this summer an instrumentation course at Case Institute. During the year, also, a special committee was set up in the computer field to obtain abstracts of available computer programs in chemical engineering which are now being published in CEP. A.I.Ch.E. will publish manuals on many of these programs if there is enough demand for them. The National Bureau of Standards asked A.I.Ch.E. to be represented on four NBS committees in addition to those in which it already has membership. Also, besides approving the production of film strips on theoretical subjects in chemical engineering, the Institute had an active publication program: its first technical manual, *Bubble-Tray Design Manual*, the result of research in the fractionation field by the Research Committee; two new standards—one for centrifugal pumps and the other on impeller-type mixers; and six new titles in the Symposium Series. In addition, Council approved a plan to be underwritten by the National Science Foundation for the translation of five Russian technical magazines.

Additional information on some important programs is carried in this issue. Council, for instance, recently agreed to join the Engineering Societies Personnel Service, which will help to implement positive aid to A.I.Ch.E. members seeking employment; one part of the effort will be the publication of a manual, *Employment Pointers for Chemical Engineers*. Council also issued a statement on A.I.Ch.E. policy as far as registration of engineers is concerned. Possibly more important than anything else, Council, deciding that the time had come for a full-fledged study of where chemical engineering is going, appointed this year a committee to study the long-range future of the profession. Besides all this, an *ad hoc* committee is even now making an intensive study of A.I.Ch.E.'s services to the members, and more progress is expected as the result of this study.

Over the course of twelve months this is an impressive record of accomplishment—especially when one adds to it the very solid achievements of the many A.I.Ch.E. committees, the Local Section programs, and the regular meetings and publications that members have come to accept as a matter of course. Surely, as the chemical engineers who are not members of A.I.Ch.E. realize the advances that the Institute is making for them year in and year out, they will want to join with us in this important work.

F.J.V.A.

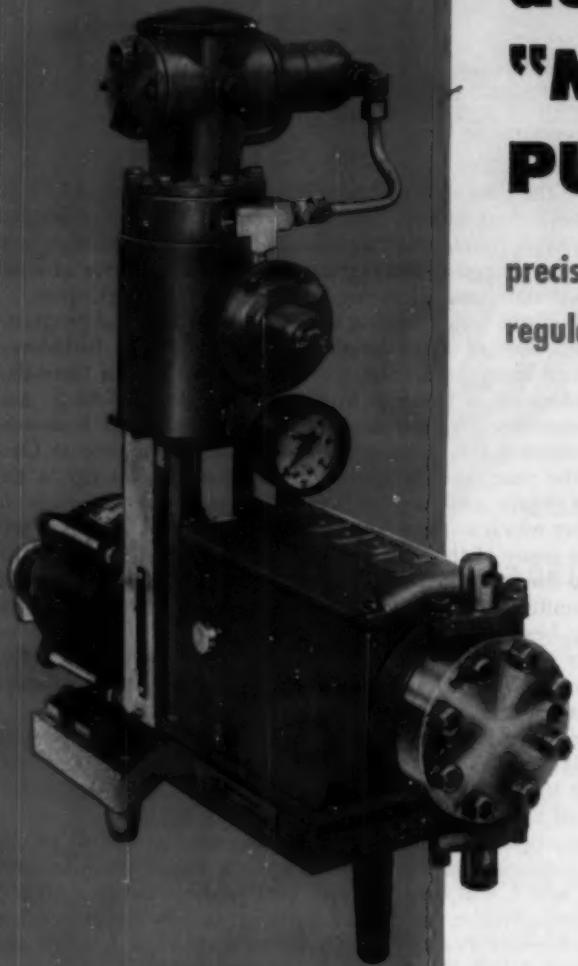
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Output of a standard Microflo is governed by controlling the travel of its piston. This is done manually through a micrometer. In the Auto-Pneumatic model, an air cylinder performs this operation. As a change in a process condition occurs, a pneumatic control instrument senses the change, records it and sends an air pressure signal descriptive of the changed condition. Auto-Pneumatic Microflo Pulsafeeder reads this air signal and changes its pumping rate accordingly.

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WRITE FOR BULLETIN 500-A containing complete description and specifications on the new Auto-Pneumatic Microflo Pulsafeeder.

Lapp Insulator Co., Inc., Process Equipment Division,
3711 Poplar Street, Le Roy, New York.

For more information, turn to Data Service card, circle No. 21



William Copulsky (l.) and Rudolf Cziner of W. R. Grace & Co. examine the results of a regression analysis for forecasting chemical sales. In this instance, Grace's IBM 650 computer was used.

Market Research *—tool for profitable operation*

RUDOLF CZINER &
WILLIAM COPULSKY,
W. R. Grace & Co.
New York, N. Y.

THE activities of the market research department of a chemical company have become an integral part of the operations of such firms since the end of the last war. In fact, so much interest has been shown concerning the role of market research in chemical engineering activity, that a full-scale session was held on it at A.I.Ch.E.'s Atlantic City Meeting.

Primary attention was focused on the interrelationship between market research and chemical engineering, including such topics as

plant location, the size and cost of plants, the use of market research in determining products specifications, and similar aspects.

As is true for any specific business activity, the chemical company requires the efforts of all technicians and managers. Neither the chemical engineer alone, nor certainly the market analyst are responsible for the success or failure of a chemical enterprise. It is the purpose of this CEP feature to show the "team effort" required for profitable operation.

*Eleven pages on the role of Market Research
and its relation to the chemical engineer*



The chemical engineer applies market research

Market research in the chemical industry

The basic function of a market research department is to prepare market studies, explained Charles F. Sanborn, senior sales representative of the Wyandotte Chemical Co., and everything else it does stems from these studies. On Figure 1, the most frequently encountered activities are listed near the center, while those engaged in by fewer departments are at the ends. The dividing line as to what market research people do is the one which separates their activities into projects on standard products which their companies have been making for years, and on new products and suggestions for new products. The activities on the left side of the chart become involved with the over-all operations of the sales department. The other side is concerned almost wholly with adding new products to the company's present line.

There are few departments set up to do everything shown in the chart, Mr. Sanborn warned. For various reasons, some try to do everything anyhow. A medium or large size company usually has a department for each operating division and a separate one

for a general development division. Some market research departments engage in development work to a fair extent. Conversely, many development departments do a considerable amount of market research. There is much unavoidable overlapping between the two functions. A distinction between the two is that market research *points* the way, whereas development *leads*

tirely with industrial products. In a consumer product company (for example, razor blades) market research investigates advertising copy, advertising media and their effectiveness, consumer sampling, brand name surveys, motivation research, etc. The chemical producer as an industrial supplier is concerned with the effectiveness of his sales program, the plant capacity, product obsolescence, product service, inventory requirements, and all facets of the business which will help to sell chemicals to a knowledgeable group of customers.

An all-day symposium on chemical market research was held at the 39th National Meeting of the A.I.Ch.E. at Atlantic City, New Jersey, on March 16, 1959. The morning session, under the chairmanship of Rudolph Cziner, Planning Manager of the Chemical Group of W. R. Grace & Co., dealt with the functions and uses of market research in the chemical company. The techniques of chemical market research were discussed in the afternoon session, directed by Dr. William Copulsky, the Director of Business Development of the Chemical Group of W. R. Grace & Co.

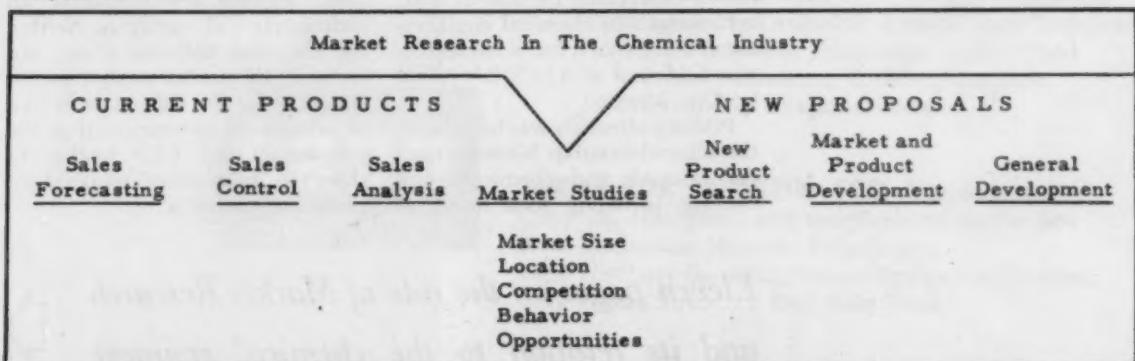
the way. In other words, where market research might suggest a new product, development will nurse the whole project to where it can stand on its own feet.

In the chemical industry, pure market research concerns itself almost en-

A thorough market study will contain accurate information on the size of a market in terms of tons, dollars, grades, packages, and all other details by which the market can be subdivided. It will pin-point each market geographically by industry and end-use, and even by each consuming plant, if possible. The report will also detail complete information about competitors, their strength and weaknesses, products, capacities, areas of operation, plans, etc. The market survey will also indicate the behavior of the market and all of its subdivisions. It will show seasonal variations, changes in the business conditions, future growth patterns and price trends.

Such a detailed and complete market survey alone is of little value, un-

Figure 1. Activities of market research departments in various companies.



less management knows how to use this information to increase its sales and profits. Such studies should usually be on a continuing basis to systematically provide management with detailed information and changes as they occur.

Mr. Sanborn continued, "There are three phases to preparing and using a market survey: 1) the collection of information, 2) the collation and correlation of this information into a meaningful report which can be interpreted in terms of the problems at hand, and 3) the use of this information in formulating a plan of action or making specific recommendations."

Even the collection of information is an art in itself. Most of the time, some sorts of data have already been collected and are available, either from the Government, trade associations, or friends in industry. The trick is to know where to find it and how to use it. Usually the figures are not exactly in the form desired; often they are out of date. The collection of information, consequently, is not strictly a librarian's job. It requires perseverance, ingenuity, a good background in the field, and a wide circle of acquaintances.

The collation and interpretation of data involve the ability to deduce a complete picture from incomplete information. This includes the ability to analyze interviews, questionnaires, call reports, magazine articles, and all other sources of information and gossip. It includes the ability to point out the special advantages or disadvantages from the company point of view. Most important, interpretation results in the forecast, in predicting what lies ahead.

A word of caution is necessary at this point. All forecasts are wrong to some extent. Knowing how to use a forecast, with its limitations, belongs to the art of management. The purpose of a forecast is to reduce risk, not to eliminate it. Actually, many market research departments make no recommendations concerning their surveys, permitting an unbiased management to evaluate their results.

Just as there is no single way of preparing a market survey or operating a market research department, there is also no single criteria on personnel. In chemical market research, chemical knowledge is important. On the other hand, a good familiarity with economics and other social sciences is also required. Communications play an all-important part. Obviously, the ideal market research man in a chemical company would seem

to be a combination of chemist, social scientist, and liberal arts student. But in most cases, the market research department consists of three or four persons. A heterogeneous mixture of specialties and backgrounds is possible. This provides the best climate for imagination and productivity, Mr. Sanborn concluded.

Plant design and location

"In the next decade, chemical market research should play an increasingly important role in influencing the design and location of plants," according to Henry E. Wessel, assistant director of Market Development for the Stauffer Chemical Company. Increasing competitive pressures from both domestic and foreign sources will place an increasing premium on favorable locations and most economic designs. Within recent years the chemical industry has seen an invasion from other sectors of our economy, as for example, the petroleum industry and rubber producers entering the chemical field on a major scale. Even the chemical industry itself is not standing still. Right now, it is moving into the energy field at two levels; in atomic energy and high energy fuels. Within the next two decades the chemist may revolutionize the metallurgical industry.

In effect, the customers and suppliers and constituents of the chemical industry are changing right now. Chemical companies are facing unfamiliar markets. To provide for future needs, the chemical market analyst will be required to determine the size, shape, and location of future plants.

Chemical plant design, of course, covers everything from metal refining to fine pharmaceuticals. The factors which determine where to locate any plant will include such major considerations as the location of raw materials, the availability of energy for other utilities, labor conditions, taxes and insurance rates, etc. For many plants, however, the location of a market becomes vital. Chemical market analysis, therefore must not only locate future markets, but by doing so, often determines both the plant location and the maximum size plant which can be built. The engineer and the market analyst usually must compromise on their best estimates. Where a 20-million pound plant may produce a product most economically, management may be forced to build at a smaller capacity, because of limitations in the market size.

Robert C. Sweeney, manager of Market Development for Sinclair

SANBORN,
Wyandotte—
Market studies
are basic.



WESSEL,
Stauffer—Market
research in
plant design
and location.



SWEENEY,
Sinclair
Petrochemicals—
New applications,
new products.



WILLIAMS,
Roger Williams
Technical &
Economic
Services—
A long-range tool
of management.



McGEE,
Arthur D. Little—
The role of
Operations
Research.



Petrochemicals, discussed the value of the market research department and market analyst in helping to locate both new uses for established products and applications for new products. He stressed that ideas come from salesmen, the research laboratory, and published sources, and indicated that the chemical market research department can prove invaluable in supplementing these idea sources, since the market analysts command a wide circle of industry contacts, often different from those seen by the sales force.

Long-range planning

Roger Williams, Jr. concluded the session on the use of chemical market research. The president of Roger Williams Technical and Economic Services

continued

continued

ices, Inc., pointed out that chemical market research is a long-range tool of management. While *sales analysis* concerns itself with the immediate future, and *marketing research* determines customer preferences, *chemical market research* deals with trends and conditions of the future.

Chemical market reports may often result in immediate action on the part of the company, as for example, a decision to build a plant. That plant, however, probably will not operate in the next two years and will not return the investment and a profit for a number of further years. Chemical management, therefore, is interested in knowing market conditions for the products of this plant at least for the next five to ten years.

Long-range market research can generally be divided into several categories. The most obvious division is usually between existing products and products new to the company. A company may also have a raw material position which it desires to upgrade to more profitable products. This is exemplified by the entry of the petroleum companies into the chemical field. In another case, a particular geographic area may be selected and studied to determine its potentials.

Similarly, a major consuming industry may be investigated to determine the size of its future demands and its needs for improved or new materials.

The virtues of long-range planning are self-evident. A company, like an individual, should set its goals. It may never achieve these, but for a company to prosper, an ambition to work for them must exist. Any management looking ahead to a general or specific goal must have some idea of its value, so that it may determine the amount of money which can be risked or gambled by attaining it. A good manager tries to minimize the odds by superior knowledge. This involves, in chemical market research, an examination of what happened in the past, what the current conditions are, and what future trends can be expected to develop, based on our current knowledge and technological know-how.

Chemical market research, thus, aids management's long-range plans in two ways. It reduces the risk on new investments. It also shows research management the relative potentials of alternative projects. For example, chemical market research should be able to tell a research director whether there is a greater potential market in developing an improved insulating material or in developing a new material for road

signs. Either project might be profitable, but under the limitations of a budget, the research director should have an opportunity to select those developments and ideas which indicate that they have the greatest potential returns.

Chemical market research, thus, is primarily a tool for long-range planning, Mr. Williams concluded. It is a service function. How well it serves will depend on the extent of its use, the expenditures involved, the adequacy of the personnel, and the attitudes of management.

Techniques

In the second part of the session, articles were discussed dealing with the methods of forecasting sales and demand, including correlation techniques and input-output analysis. One important aspect was the use of operations research in market research problems. John F. Magee, head of the Operations Research Group of Arthur D. Little, Inc., reported on the development of a model describing customer account activity and the selection of accounts for sales promotion effort. Continuing work has led to the development of a new type of model (mathematical system) which can be used to estimate the long-term value of promotion of a particular type of customer.

Sales forecasting

RICHARD BERGER
General Aniline & Film Corp.
New York, N. Y.

The general aim of either sales or economic forecasting is to provide management with reliable advance information on future business conditions. In the final analysis, forecasts, by whatever means obtained, must be modified and used in terms of an executive's personal judgment and special knowledge of the business.

A forecast is an estimate based on a set of assumptions which are most likely to occur. Such basic assumptions must underlie any sales forecast. These assumptions should be clearly defined.

Forecasts can be either of a long-term or short-term nature. A short-

term forecast usually is for one year or less, while a long-term forecast is generally longer than a year's duration. Of course, companies or individuals may vary somewhat as to these definitions. Short-term forecasts are used for inventory policies, pricing, wage and salary policies, employment policies, purchasing schedules, determination of sales quotas, budgeting, production planning, etc.

On the other hand, long-term forecasts are used to set capital investment policies, to make disinvestment decisions, for long-term borrowings, and other managerial considerations.

Certain criteria can be established

to judge the various forecasting methods. The forecasts should be based on scientific methods, that is, on organized knowledge used to explore cause and effect relationships. The methods should allow the determination and measurement, even if inexact, of such relationships. The analytical methods must be of such a nature that they can be used for forecasting purposes. The methods must be based on the use of available data. The methods should be inexpensive in terms of time and manpower, as related to the accuracy and value of the results obtained. Finally, and most important, the methods

should work empirically and provide useful forecasts.

Every sales forecast has two basic elements, external and internal forces. A company has little or no control over external forces (consumer income or competitive prices). But the company does control the internal forces in that it sets its own policies (inventory, type of product carried, or the quality of the product).

Non-numerical methods

Non-numerical forecasting techniques can be classified in five categories:

1. consensus of executive opinion.
2. sales managers' estimates.
3. historical analogy.
4. composite by industry experts.
5. sampling of group opinions.

The **Consensus of Executive Opinion** consists, simply, of the majority views of top executives of a company, who meet periodically to review the company's prospects. As a first step, background material and data are prepared and examined before the meetings. The material is reviewed at the meeting and views are expressed concerning the data and the future outlook. The chairman arrives at a consensus and the group abides by the result. The executives should know the firm and be more or less responsible for its success (or failure). On the surface, this method is less expensive than maintaining an economic research staff. It allows each key man the opportunity to make a direct contribution to the forecast. A quick alteration in forecasts can also be made to take care of unforeseen events.

However, there are some definite disadvantages to such a method. Some of these men may be unaware of underlying national events or economic trends. Underlying assumptions are not usually emphasized in executive sessions. If a forecast is in error, it may be difficult to determine which assumption was wrong. Certainly, this method often lacks objectivity. Such forecasts usually are limited in application, since they often are not set forth in enough detail.

With the **Sales Managers' Estimates**, often known as the "grass-roots" approach, a company relies on its sales manager to get estimates. In theory, he is close to the consumer and has a feel of the situation. In this method, either a questionnaire is sent to each member of the sales force to determine future estimates, or estimates are made by salesmen in consultation with the branch or regional manager. Usually, the estimators have a record of past sales in order to make realistic

estimates. These are compiled for each branch or district and forwarded to the central office, where a composite forecast is derived. Some companies do not use individual salesmen, but rely on the specialized knowledge of the sales executive staff, like district or product managers.

This sales forecasting method utilizes the men closest to the market. Responsibility is placed in the hands of those most directly concerned with sales. The sales force usually has confidence in quotas developed from these forecasts. On the other hand, sales managers are often either unaware of national developments and trends, or are unable to translate these conditions to sales. Their forecasts are based mostly on past experience and personal psychology. In a period of declining sales, they tend to become overly pessimistic, and vice versa. Besides, these activities require an extensive expenditure of time by executives and the sales force.

The third approach, **Historical Analogy**, has only limited usefulness. Sales are examined in terms of past performance in an attempt to select a period in history with conditions similar to the period undergoing forecast. This can be useful for a company



From wartime OPA, through Dun & Bradstreet, to his present position, sales forecasting has become second nature to Berger.

with a new product, trying to use the experience of a company selling the same, or a similar product. However, rarely will economic conditions be similar to two periods. Perhaps this method should be used only to confirm other methods, or, if no other method is available.

In the fourth non-numerical method, the **Composite by Industry Experts**, a company simply hires individual experts in various fields. Periodically, these experts are asked to submit forecasts. Usually, one person in the company will take the forecasts, evaluate them, and develop a combined figure. This procedure uses specialists with supposedly good contacts in their particular fields. However, it may be difficult to correlate the several parts since they may be based on different assumptions.

Finally, there is the **Sampling of Group Opinions** method. In this tech-

nique, sampling surveys are conducted among consumers and customers. For most companies, this can be a very expensive method, involving sampling, follow-ups, sub-sampling of non-respondents, etc. Often, the entire survey must be rerun to see if opinions have changed.

Numerical methods

Numerical methods of sales forecasting can be classified into those involving trends and cycles, and those involving correlations. Another method is called the **Input-Output Analysis**. There are also many mathematical formulas used for forecasting.

The sales volume of any company is largely the result of four factors: long-term growth trends, cyclical business fluctuations, seasonal variations, and irregular variations. Unfortunately for the trend method of forecasting, there are too few companies where the patterns of these four factors are so well defined that the use of this system proves profitable. In most industries, this method is used chiefly for long-range forecasting rather than short-range, since results are not usually accurate for month-to-month planning. Moreover, the error involved in missing peak sales by two or three months in a period, say five years from now, would not seriously affect the financing of new plant and equipment for that period. However, it could affect seriously the profit or inventory pictures in a particular year.

Much work has been done on developing trends, cycles, and seasonal variations. Briefly, the trend is obtained in measurable units. The other factors are obtained as percentages. Thus, to get a particular forecast, the four factors are combined. The trend factor is multiplied by the three other percentage factors, the **cycle**, the **seasonal**, and the **irregular**. In terms of symbols, it would be $TCSI$. If annual forecasts are required, the seasonal factors can be ignored. Only the trend, cycle, and irregular components need be used.

Very often, the only method used by a company to make a sales forecast is the trend alone. This is especially true when the company does not know, or is unaware, of underlying economic factors affecting a company's future. There can be many types of trends: linear, logarithmic, or curvilinear. In practice, linear or logarithmic are most often used. If the trend appears to be a straight line plotted on semilog paper, it indicates

continued

Sales forecasting

continued

that sales are increasing at a constant percentage rate for that company. This is commonly the case. In determining trend lines, it is often necessary to eliminate certain time periods in which random factors have occurred. These periods tend to distort the trend. For example, war periods usually show higher than normal sales.

The theory of least-squares is used in determining most trend lines. In applying this theory, a line is obtained which gives a so-called "best-fit." The sum of the squared deviations of points around this line is less than that from any other line that might be fitted to the data. With practice, obtaining trends by sight is almost as useful and certainly less time consuming.

Cycle analysis has captured the interests of economists and businessmen for many years. The National Bureau of Economic Research has been studying cycles for decades. Actually, a perfect theory of business cycles has yet to be formulated. Since the subject has not been fully developed, many companies are wary of using cycles in their forecasting. However, it is possible to try to develop a cycle

of company sales. Usually, cycles are obtained by a process of elimination. First, the trend is developed. The original data are then divided by these trend estimates for each year. Only the cycle and irregular factors are left in the data. By a smoothing-out process, usually by sight, a cycle can be developed. With each of the components of a time series developed, each component is forecast for the period under review. These individual forecasts can then be combined into an over-all sales forecast.

The correlation method of sales forecasting has proven to be one of the most satisfactory methods of forecasting for many companies. Actually, it is simply a method of measuring the relation between two or more factors. For example, a direct relation may be discovered between the Federal Reserve Board Index of Industrial Production and the unit sales of a product or group of products a particular company sells. Since the FRB Index (or various other national measures) are forecast by many experts, a forecast for the correlated sales product is possible.

Another forecasting method which might prove useful if the data ever become available is the Input-Output method. It depends on a complete analysis of what a particular industry requires and where its products are

sold. Aside from an attempt in 1947, no Input-Output tables have been prepared for use by industry.

Conclusions

The methods of sales forecasting that can and should be used, of course, depend on several factors. Operating executives should be able to understand the methods used, otherwise their confidence in them is lessened. The method adopted should result in fairly accurate forecasts. Nothing destroys confidence like consistently bad forecasts, or for that matter, one bad forecast. The cost of making the forecast and the amount of work involved should be considered against the possible benefits to be derived from it. Usually a combination of methods will provide the best results.

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Correlation analysis



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Correlation analysis in forecasting the demand or supply for a chemical involves determining and measuring its relationship to a certain economic or other factor, or group of factors. The future of the chemical can be determined on the basis of these measurements (and certain further assumptions). This is possible if forecasts can be made, or are available for the economic factor, usually true for national economic data like the Gross National Product, production indexes, etc.

In a very simple example, the national demand for sulfuric acid (the

dependent variable) can be correlated mathematically to an index of national industrial production activity (the independent variable). Since many expert forecasts are available on future industrial production rates (or rates of increases), the correlation equation will yield a forecast for future acid needs.

Correlation equations are designed to make use of only major factors which account for most of the variations in the data. It is assumed that the net result of the many other minor forces will interact in a random way, so that the small residuals not accounted for are randomly dis-

tributed. Often, however, such minor factors become of enough importance to render the historical relationship valueless without modification. The correlation equation is a practical device of use in forecasting, but its value is only determined by its success in actual use.

The correlation technique has many limitations that make it a dangerous tool in the hands of the unskilled. Above all, the basic economic relationships must be understood before correlation equations are established. The use of economic flow diagrams and models is a valuable aid in this regard.

Some analysts try to get as perfect a fit as possible with their regression (correlation) equations. Most experienced analysts, however, concentrate on explaining as substantial a part of the variations as possible. Imperfection of fit is not only caused by partial or incorrect explanation of variation, such as by omission of variables, but also by errors in data, and intercorrelation of independent variables. Even closeness of fit does not indicate success in forecasting. The residuals from regression equations should be carefully studied, and if they are not small and random, they must be explainable if the equation is to be useful.

The analyst must understand that large residuals of the regression will occur in the future if there are factors, negligible in the past, which will have an important influence in the future, if any time leads and lags are likely to remain the same in the future. These are only some of the problems involved in extrapolating regressions into the future.

Statistical tests of significance are

usually used to determine the reliance of a mathematical correlation. Such statistical tests are based on probability theory, which does not strictly cover economic time series, due to the presence of serial correlation and interdependence of successive observations. Regression equations are usually of demonstrated value if the tests of significance indicate that over 80% of the variation has been explained by the equation.

Most forecasters do not rely solely on statistical tests of significance, but on empirical testing of relationships in actual forecasts and on the use of common sense in formulating relationships that reflect economic realities.

Soda ash, caustic soda, and chlorine

It has been known for many years that the sales and production of the chlor-alkali industry tend to follow general business fluctuations. Until recently, little, if any, attempt was made to measure the degree of change in industry and company sales in response to changes in general business activities. To improve the reliability of annual sales forecasts as a basis for sales planning, production scheduling, general budgeting, and other planning activities, a study to measure the relationship between general business conditions, industry sales, and company sales was initiated.

The questions to be answered for each product were as follows:

1. What would have been the growth rates of the three products, had general economic conditions not changed?

2. How sensitive were these products to cyclical swings? The answers

to these questions would, in turn, provide the answers to two further questions:

3. How did company sales grow relative to the industry?

4. How did company sales fluctuate relative to the industry?

There was also a need to keep relationships in the simplest possible form to make frequent and timely forecasts. These relationships were believed to be simple for many reasons: Industry sales of these products should not be significantly affected by short-run price changes. The price-volume relationship for each of the products is highly inelastic in the short run. There also is practically no inter-product competition between chlorine and the other two. Further, small changes in the relative prices of soda ash and caustic soda probably do not cause a short-term switch from one product to the other, even though they are chemically interchangeable for many uses. Significant encroachment of other chemicals on these products, or vice versa, is usually of long-term nature. Thus, the substitution effect may be disregarded in computing annual forecasts.

Since the end-uses of these products are highly diversified, general economic conditions may be the only indicator of changes in their respective demands.

The analysis of the data was generally similar to other studies in correlations. In this particular case, the year-to-year fluctuations seemed simple enough to be explainable only by two factors: the natural growth rate and the ups and downs of general business activities. Since the questions to be answered required percentage

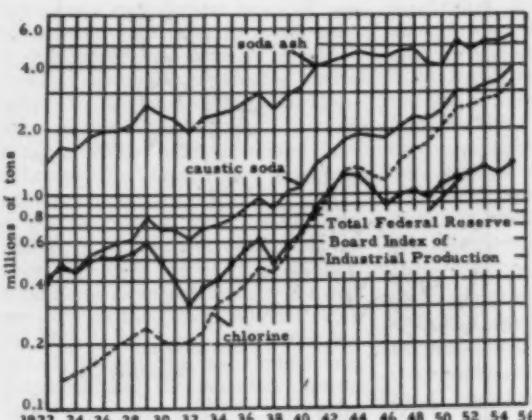


Figure 1. Production of soda ash, caustic soda, and chlorine vs. total Federal Reserve Board Index of Industrial Production, 1922-1955.

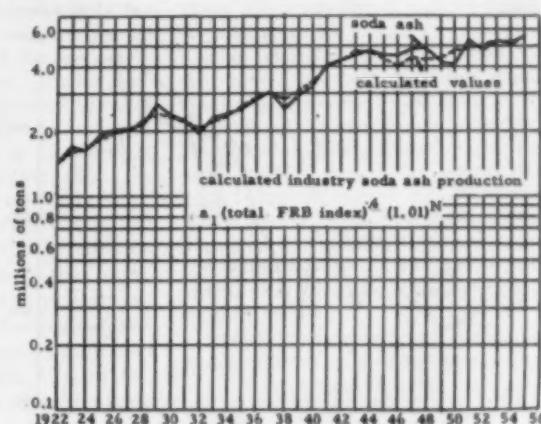


Figure 2. Comparison of calculated soda ash production based on Federal Reserve Board Index of Industrial Production, with actual soda ash production, 1922-1955.

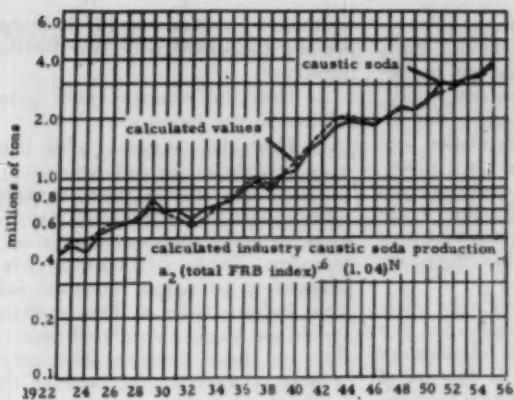


Figure 3. Comparison of calculated caustic soda production based on Federal Reserve Board Index of Industrial Production, with actual caustic soda production, 1922-1955.

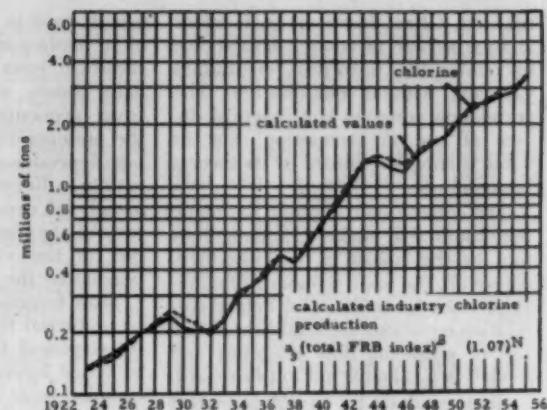


Figure 4. Comparison of calculated chlorine production based on Federal Reserve Board Index of Industrial Production, with actual chlorine production, 1922-1955.

Correlation analysis

continued

expressions, a correlation of the following general form was indicated:

$$Y = aX^b c^N \quad (1)$$

Where: Y = Industry volume

X = A general economic index

N = Time (years)

a , b , and c = constants

The constants are to be determined mathematically for each product. The general economic index (yet to be selected) and time, N , are the independent variables. The product volume, Y , is the dependent variable.

The Federal Reserve Board Index of Industrial Production was chosen in preference to Gross National Product, and the Index of Non-Durable Goods Production. The Gross National Product series did not give as close a correlation as the production indexes. The non-durable goods index would have been preferred, if it had been as widely analyzed and forecasted as the total FRB index by various government agencies and other experts. The various data are shown in Figure 1.

Industry production data were used, since production statistics from the government are much more reliable than sales or consumption figures estimated by private sources. In addition, the alkali and chlorine industry seldom carries large quantities of inventories for these products. Year-to-year inventory fluctuations were very small.

Equation (1), fitted to the three products and the FRB index, results in Equations (2), (3), and (4) below. The production data calculated from these equations are compared to the actual data in Figures 2, 3, and 4, respectively.

$$Y_1 = a_1 X^{0.4} (1.01)^N \quad (2)$$

$$Y_2 = a_2 X^{0.6} (1.04)^N \quad (3)$$

$$Y_3 = a_3 X^{0.8} (1.07)^N \quad (4)$$

Where: N = Time (years), from $N=1$, 2, 3, ..., n

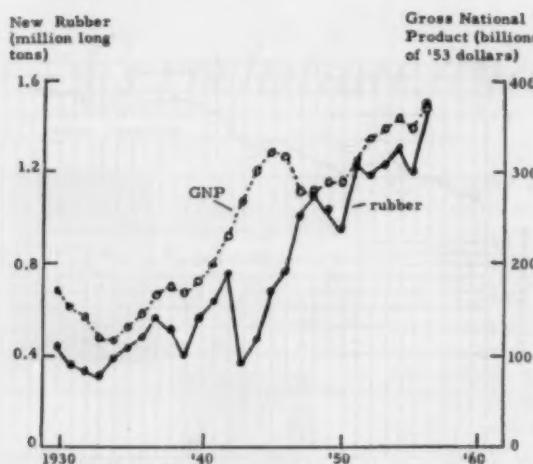


Figure 5. United States consumption of new rubber and gross national product.

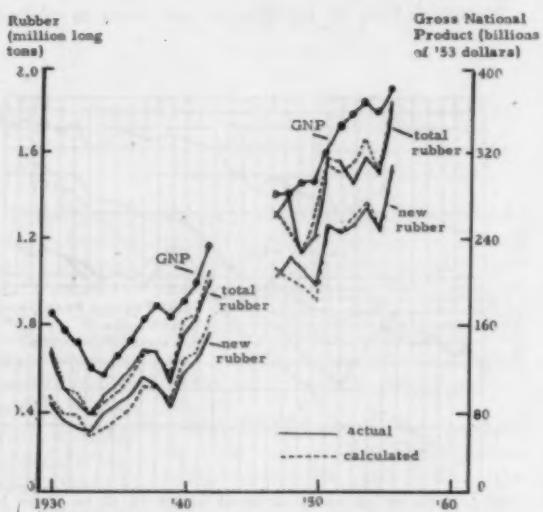


Figure 6. United States consumption of new and total rubber, actual and calculated, and gross national product.

$$\begin{aligned}
 X &= \text{FRB Index of Industrial Production} \\
 Y_1 &= \text{Industry soda ash production} \\
 Y_2 &= \text{Industry caustic soda production} \\
 Y_3 &= \text{Industry chlorine production}
 \end{aligned}$$

These equations fitted the actual values well. The year-to-year variations between actual production and computed production (or between actual and computed sales) seldom differed by more than 10%, except for the war years (which were initially excluded from the correlations). In fact, computed figures are generally within 5% of actual data, thus substantiating the belief that these products fluctuate closely with general business conditions.

From these equations, it can be seen that the expected growth rates, apart from changes in general economic conditions, are respectively 1%, 4%, and 7% per year.

U. S. rubber demand

In connection with a butadiene market study, forecasts of total rubber demand in the U. S. were required. Since the primary use of butadiene is in GR-S synthetic rubber (now called S-type), forecasts of total rubber demand minus forecasts of natural rubber supply (and price) would yield total synthetic rubber demand and, by simple arithmetic, butadiene requirements.

Of the various calculations made, it was found that only the forecast of total rubber demand could be treated by correlation methods. It is recognized that rubber demand is highly complicated. It is affected in different ways by the production of new automotive vehicles, as well as by automotive replacement demand, and by demand for rubber for other uses. A detailed end-use analysis of rubber demand would be a valuable contribution to this type of analysis. However, in this case, the use of a short-cut correlation method, taking considerably less time, gives adequate results.

In this case it was first assumed that U. S. total rubber demand would vary only with the level of business conditions, as represented by a measure such as the Gross National Product (GNP) (Figure 5). The first approach to test this assumption was graphical, and the equation derived was:

$$Y = 4.08X - 180 \quad (5)$$

Where Y = U. S. new rubber consumption (thousands of long tons)

$$X = \text{GNP (billions of 1953 dollars)}$$

The GNP was expressed in constant dollars, since rubber consumption was measured physically.

From the graphically derived relations, it was found that the calculated figures obtained tended to agree with the actual figures, except during declining and advancing periods of demand, as in the period 1929 to 1939, where the effect of accumulated inventories probably threw off the estimates. Consumption by rubber product manufacturers (not by ultimate consumers) does not take into account inventories of finished products held by manufacturers, distributors, and users. Since such data are not available, a measurement of consumption by ultimate consumers of rubber is not possible. In addition, the figures used represent only consumption of new rubber and do not include reclaimed rubber. It competes with new rubbers to some degree.

In the next step of the analysis, total rubber consumption in the United States (synthetic, natural, and reclaimed) was plotted on the ordinate-axis of Figure 6 (as the dependent variable Y) versus the GNP on the abscissa-axis (as the independent variable X).

Examination of this scatter diagram showed that in years of declining rubber consumption the points fell below the line of relationship, in years of increasing consumption the points tended to fall above the line. Also (as was to be expected) the war years, 1942 to 1945, did not fit into the relation and so were omitted from consideration as unrepresentative. During this wartime period, natural rubber imports fell off due to fighting in the producing areas. Synthetic rubber production was initiated, but not enough was available to meet the demands of all sectors of the economy.

As stated, these discrepancies from the line of relation appeared to result from the fact that rubber consumption in the available data is measured at the manufacturer's rather than the consumer's level. The consumer, however, can obtain his needs from either the manufacturer or from inventories. If the assumption is made that inventories are proportional to rubber consumption, inventory fluctuations will be proportional to changes in rubber consumption. Therefore, a third factor X_2 , the change in rubber consumption over the previous year, was introduced.

By least-squares multiple regression, using the years 1929 to 1941,

and 1946 to 1953, the following equation was calculated:

$$Y = -187 + 4.928X_1 + 0.444X_2 \quad (6)$$

Where:

$$Y = \text{U. S. total rubber consumption (natural, synthetic and reclaim)}$$

$$X_1 = \text{GNP}$$

$$X_2 = \text{change in rubber consumption over the previous year (thousands of long tons).}$$

When applied to the actual value for the years 1929 to 1941, and 1946 to 1953, the average error was only 4%.

Considering only new rubber, it was decided that a relation could also be obtained, of use for forecasting new rubber consumption, without the necessity of estimating reclaimed rubber use. Reclaim use was becoming a small percent of total rubber, declining from 32% in 1929 to 18% in 1953.

The derived equation, using the years 1929 to 1941, and 1946 to 1953, is:

$$Y = -204 + 4.18X_1 + 0.404X_2 \quad (7)$$

Where:

$$Y = \text{New rubber consumption}$$

$$X_1 = \text{GNP}$$

$$X_2 = \text{the change in new rubber consumption over the previous year.}$$

The coefficients (it will be noted) are very similar to those in the equation for total rubber consumption, and to those indicated in the original simple graphical approach.

Using Equation (7), the percent error is very small in recent years, although it averages 7% for the period in which Equation (6) gave an average 4% error. The error should remain much smaller in the future since reclaim use is running at a fairly stable level (Figure 6).

The reliability of these equations was shown by their fit to the actual results in the years 1954 and 1955, which were not used in computing the relationships. Using Equation (6) for total rubber, the actual figure was 1.1% below calculated for 1954 and 0.4% above calculated for 1955. Using Equation (7) for new rubber only, the actual figure was 0.2% below calculated for 1954, and 1.9% above calculated for 1955.

Correlation analysis as indicated above is a useful tool for forecasting in chemical market research, provided its use is well understood and its limitations recognized. This strictly mathematical approach must be supplemented by expert market know-how.



Input-Output

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Input-output analysis concerns a relatively little-known approach to market research and related subjects. Input-output, also known as inter-industry studies, is a much neglected tool in economic research.

In recent years, Professor Wassily Leontief of Harvard University recognized the idea was not only a useful tool for the theoretician, but was a practical means of attacking some of the most complex real problems of the modern industrial economic environment. Leontief's research, started in the early thirties, culminated in the massive analysis by the Bureau of Labor Statistics of the United States economy for 1947. From this study was produced the well known 50-order tables, the lesser known 200-order tables, and back of this, a much greater detailed report for many separate industries.

The input-output technique is exactly what its name implies. Its final representation is in the form of a square table. The economy, for example, is divided into a defined number of sectors. Table 1 depicts part of such a study for the economy of 1947, with 50 sectors.

Each science, discipline, or art seems to have its own form of graphic representation. The inter-industry matrix can be considered akin to a chemical reaction. To achieve a certain result, an output, there must be

a precise input of materials, energies, etc., in a specific environment. The inter-industry studies likewise deal with balanced inputs and outputs. Unfortunately, the economist cannot work with a controlled environment, and the inputs and outputs are more variable than those of the physical scientists. These factors cause the imbalances in economic affairs which create the disturbance in business conditions. The input-output studies, however, if used diligently, can improve market forecasts and minimize business fluctuations.

Each row in Table 1 records the receipt by, or demand from, other sectors of industry. Each column shows the disbursements of industry to other sectors. Thus, the rows represent the outputs to the several sectors, while the column figures show the inputs from various sectors, or the inputs required to produce the output of the sector. This assumes that the production delivered from one industry to another is required by the second industry to achieve its output. Further, use of the technique assumes that changes in output will be linearly related to demands on other sectors. This may not be so, but further research will permit the development of non-linear relationships.

If such tables are used in dollar terms, the further assumption is made that dollar relationships are constant. Again, this is (at least) questionable,

Table 4. Major outputs—the plastics materials industries 1947

PRODUCERS' VALUE
(In thousands)

1. Paints, varnish, etc.	\$92,196
2. Plastic products	91,078
3. Paper products	35,399
4. Insulated wire and cable	17,580
5. Handbags and purses . . .	15,373
6. Electrical control apparatus	14,121
7. Coated fabrics	13,412
8. Bread and bakery products	10,811
9. Cigarettes	10,592
10. Confectionery products	9,215
11. Flat glass and glass products	9,184
12. Wiring devices	8,441
13. Buttons	8,000
14. Telephone and telegraph equipment	7,829
15. Rubber products n.e.c.	7,281
16. Phonograph records	7,154
17. Plywood plants	6,985
18. Electrical appliances	6,450
19. Cotton and rayon textiles	6,204
20. Footwear	5,812
21. Asbestos products	5,280
22. Radios	5,265

but many times a table can be transformed into quantitative terms.

Table 2 shows the data of Table 1 converted to cents of purchases from other sectors, per dollar of output by a given industry. For instance, the column labeled "Agriculture" shows that to produce one dollar of product required 28.1 cents from other agriculture (feed and seed), 2.0 cents from the chemical sector (fertilizer, pesticides, etc.), and 0.004 cents from lumber products, etc.

The plastics materials industry

A specific case in which the input-output technique is useful in market research can be demonstrated with the

INDUSTRY PURCHASING	INDUSTRY PURCHASING									
	1. agriculture & fisheries	2. food & kindred products	3. tobacco manufactures	4. textile mill products	5. apparel	6. lumber & wood products	7. furniture & fixtures	8. paper & allied products	9. printing & publishing	10. chemicals
1. agriculture & fisheries	10,040 15,040	783 11,079	19 100	669 21 9,793	44,653					
2. food & kindred products	3,378 4,700	19 68	9 0	728 22 22,143	37,636					
3. tobacco manufactures	—	836	—	5 2	4,463 2,663					
4. textile mill products	64 2	1,303 3,688	3 100	101 11 1,659 9,616						
5. apparel	44 204	— 1,943	—	192 1 9,907 13,321						
6. lumber & wood products	148 61 18 10	21 1,094	10 10	10 16 67 6,002						
7. furniture & fixtures	—	— 12	—	32 506 1,699 2,070						
8. paper & allied products	2 630 65 78 20 6	99 344 7,899	—	104 65 1,090 6,567						
9. printing & publishing	— 39 2	—	—	104 65 1,090 6,567						
10. chemicals	130 1,051 25 800 145 246	184 1,964 16,000	—	177 9 2,437 13,570						
11. petroleum & coal	687 68 4 30 3 76	—	—	—	—	—	—	—	—	—
48. government	813 1,134 106 520	236 3,488	216 31,304	63,603						
49. gross private capital	15,246 6,282 307	—	—	—	—	—	—	—	—	—
50. nonresidential	15,246 6,282 307	—	—	—	—	—	—	—	—	—
total gross output	94,245 37,626 2,466	11,322 6,000	11,080 33,314 271,823	701,244						

Table 1. Sample section of typical Bureau of Labor Statistics 50-order table for 1947.

INDUSTRY PURCHASING	INDUSTRY PURCHASING									
	1. agriculture & fisheries	2. food & kindred products	3. tobacco manufactures	4. textile mill products	5. apparel	6. lumber & wood products	7. furniture & fixtures	8. paper & allied products	9. printing & publishing	10. chemicals
1. agriculture & fisheries	10,040 15,040	783 11,079	19 100	669 21 9,793	44,653					
2. food & kindred products	3,378 4,700	19 68	9 0	728 22 22,143	37,636					
3. tobacco manufactures	—	836	—	5 2	4,463 2,663					
4. textile mill products	64 2	1,303 3,688	3 100	101 11 1,659 9,616						
5. apparel	44 204	— 1,943	—	192 1 9,907 13,321						
6. lumber & wood products	148 61 18 10	21 1,094	10 10	10 16 67 6,002						
7. furniture & fixtures	—	— 12	—	32 506 1,699 2,070						
8. paper & allied products	2 630 65 78 20 6	99 344 7,899	—	104 65 1,090 6,567						
9. printing & publishing	— 39 2	—	—	104 65 1,090 6,567						
10. chemicals	130 1,051 25 800 145 246	184 1,964 16,000	—	177 9 2,437 13,570						
total gross output	94,245 37,626 2,466	11,322 6,000	11,080 33,314 271,823	701,244						

Table 2. Sample section of another BLS table in which the same data in Table 1 is converted to cents of purchase per dollar of output.

data available on the plastics industry. To construct this analysis, the Bureau of Labor Statistics Report No. 30 from the 1947 study must be used. Of course the data are obsolete, but this is the penalty of no work during one of the most dynamic decades of American history. Nevertheless, the use of this material permits a good insight into the technique.

Table 3 presents the inputs and outputs in accounting form, and depicts the 1947 transactions in broad outline. The plastics industry had direct inputs and outputs of \$491,192,000. Materials, fuel, electricity, and contract work amounted to \$282,652,000. Non-material inputs amounted to \$208,540,000, of which \$199,948,000 were factor payments (largely labor inputs) and other charges. The major output, almost entirely primary product shipments, amounting to \$429,572,000, were direct shipments to other sectors.

This last amount is the area of major interest from a market research point of view. Table 4 summarizes important items from Table III in BLS Report No. 30. Producers' values are shown.

Of a total value of \$530,859,000, about 10 percent, or \$54,226,000, went to final demand sectors, most of which was for export. Most of the rest of the product went to intermediate sectors, i.e., those who were going to use the products of the Plastics Materials Industries for the output of their products. Some 140 such intermediate sectors are shown. Here, then, are shown the relative importance of various sectors as consumers of the output of the Plastics Materials Industry.

Reference to corresponding studies for these output or consuming industries will give a ratio of demand for plastics materials to output of those industries. The data in Table 5 were developed from Table II of the BLS report, showing input materials required to produce the product of the Plastics Materials Industries. Table II covers some 60-odd materials, of which 19 of the more important were selected for this analysis.

This particular report gives both dollar and quantity inputs. Thus, to produce the product of this industry required \$15,275,000 for 108,592 tons of wood pulp, or, \$10,548,000 for 294,638,607 pounds of formaldehyde.

A theoretical forecast for the Plastics Materials Industry is made on Table 6. All the items on Table 4 have been assumed to have increased their industry output from zero to 20 percent. A random number table was

Table 3. Summary of transactions, 1947: the plastics materials industry (I-O 2823).

	INPUT	OUTPUT	
A. Total inputs to primary industry	\$491,192	A. Total production by primary industry	\$491,192
1. Cost of materials, fuel, electricity, and contract work	282,652	1. Direct allocations	429,572
2. Nonmaterial charges	208,540	a. Primary product shipments	429,172
a. Purchased services	8,592	b. Miscellaneous receipts	400
b. Factor payments and other charges	199,948	2. Transfers-out	53,892
B. Transfers-in	101,624	a. Secondary products	43,312
1. Other domestic industries	101,020	b. Scrap and salable refuse	10,577
a. I-O 2295 Coated fabrics	6,730	c. Electric energy sales	3
b. I-O 2829 Organic chemicals	44,657	3. Inventory change (finished product)	7,728
c. I-O 2851 Paints, varnish, etc.	11,193	B. Transfers-in	101,624
d. I-O 2862 Softwood distillation	6,219		
e. I-O 2899 Chemical products, n.e.c.	1,008		
f. I-O 3971 Plastic products	12,068		
g. Unidentified industries	19,145		
2. Competitive imports	604		
a. Foreign port value	427		
b. Duty	120		
c. Ocean freight	40		
d. Ocean insurance	8		
C. Gross input	\$592,816	C. Gross output	\$592,816

used to associate these increases with the industries. Thereafter an input coefficient of the Plastics Materials Industry was developed for each industry, per dollar of its output, that is, inputs of plastics materials per dollar of these industries' output. These are the outputs of the Plastics

Materials Industries that become the inputs of the other industries. Again the assumption was made that the Plastics Materials Industries had outputs only to the sectors listed. An over-all increase of 7% of output was derived in this manner for the total Plastics Materials Industries. Actually,

Table 5. Selected inputs—plastics materials industries.

	VALUE (In thousands)	QUANTITY
A. Materials, fuels, electricity and supplies		
1. Plasticizers	\$26,130	62,000 M Lb.
2. Soap and related products	25,166	n.a.
3. Vinyl Chloride	20,177	144,418 M Lb.
4. Cellulose acetate	16,920	47,000 M Lb.
5. Wood pulp	15,275	108,592 ton
6. Phenol	14,866	148,962 M Lb.
7. Railroads	13,298	n.a.
8. Primary vegetable oils	12,263	44,558 M Lb.
9. Paper drums	10,893	n.a.
10. Formaldehyde	10,548	294,639 M Lb.
11. Cellulose esters and ethers	9,237	n.a.
12. Styrene	9,000	100,000 M Lb.
13. Vulcanized fiber stock	8,866	30,303 ton
14. Rosin	8,236	207,569 drums
15. Fuels and purchased electric energy	7,908	n.a.
16. Phthalic anhydride	6,400	40,000 M Lb.
17. Industrial ethyl alcohol	5,119	5,119 M Gal.
B. Non-material charges		
1. Wages and Salaries	96,664	
2. Federal Taxes	27,819	

Table 6. Example of a market forecast.

Industry	Assumed Increase in Output Industries	Estimated Increase in Output Industries		Coefficient of Input by Plastics Materials	Impact on Plastics Materials Industries (Million \$)	Output of Plastics Materials Industry	
		Year 1 to Year 2	Sales			Year 1	Year 2
Paints and allied products	+15	244.1	5.80	14.2	94.3	108.5	
Plastic products	+7	38.2	16.71	6.4	91.1	97.5	
Converted paper products	+10	340.4	1.04	3.5	35.4	38.9	
Insulated wire and cable	+12	121.0	1.74	2.1	17.6	19.7	
House furnishing and other non-apparel items	+8	144.4	0.95	1.4	17.1	18.5	
Bakery products	+20	670.4	0.43	2.9	14.5	17.4	
Tobacco manufactures	+3	77.0	0.56	0.4	14.4	14.8	
Electrical control apparatus	+2	14.0	2.01	0.3	14.1	14.4	
Miscellaneous food products	+16	1061.3	0.16	1.7	10.4	12.1	
Miscellaneous rubber products	+19	253.5	0.74	1.9	9.9	11.8	
Footwear	0	0	0.44	0	9.4	9.4	
Glass	+13	149.8	0.80	1.2	9.2	10.4	
Wiring devices and graphite products	+19	97.3	1.64	1.6	8.4	10.0	
Communications Equipment	+20	155.6	1.07	1.7	8.3	10.0	
Plywood	+10	27.6	2.54	0.7	7.0	7.7	
Asbestos products	+6	21.8	1.87	0.4	6.8	7.2	
Electrical appliances	+11	167.8	0.44	0.7	6.7	7.4	
Spinning, weaving and dyeing	+18	1457.3	0.08	1.2	6.2	7.4	
Toys and sporting goods	+7	42.0	0.92	0.4	5.5	5.9	
Radios and related products	+16	259.2	0.33	0.9	5.3	6.2	
Other	0	0	0	0	200.6	200.6	
Total					43.6	592.2	635.8

continued

it should be possible to get forecasts of changes in outputs for the several industries. Although it is known in advance that forecasts are going to be wrong, this technique permits us to evaluate the projected forecasts of the several industries into impacts on the industries we are concerned with, in this case, Plastics Materials.

An individual company can develop corresponding market forecasts on the basis of forecast sales of its customers and appropriate coefficients of ma-

terials required to meet these customers' sales. Forecasts can be developed for any forward period on the basis of forward projections of the output industries' levels of activity. Coefficients of imports to sales levels can be modified for anticipated technological changes. Hence, a range of potential markets can be projected.

The input-output technique systematizes many of the methods now used by market researchers. Too often today's procedures use gross approxi-

mations, some imagination, and a few gaps or omitted areas.

Other uses

The input-output technique can also be used in other ways. The inputs to the Plastics Materials Industries shown in Table 5 indicate the resources needed to meet market forecasts. Table 6 shows these resource needs for the assumed changes from year 1 to year 2. The technique is the same as that used to get the output, or sales forecast above.

At this point a series of analyses can be made. First, the need for new capacity may be indicated by comparing the market forecast of the industry sales with the capacity. Next, if the input or resource needs are compared with the forecast market sales, potential shortages of resources may be spotted and methods devised for coping with these shortages.

Analyses of the demand-supply relationship of both inputs and outputs are an aid in anticipating longer term price movements.

The outlined system may appear cumbersome or impractical. The original tables and supporting detail are certainly time-consuming and costly to prepare. However, once up-to-date inter-industry tables are made available, it should be possible to forecast markets in considerable detail, and should add a tool for improved decision making by American Industry.

Table 7. Changes in input or resource needs for plastics materials industry.

Year 1 to Year 2	Coefficient of Input per Dollar of Output (%)	Assumed Output of Plastics Materials	Calculated		(Millions of Dollars)			
			Industry	Input		Year 1	Year 2	Needs
Plasticizers	4.41			28.0		26.1		
Soap & related products	4.25			27.0		25.2		
Vinyl chloride	3.41			21.7		20.2		
Cellulose acetate	2.86			18.2		16.9		
Wood pulp	2.58			16.4		15.3		
Phenol	2.52			16.0		14.9		
Railroads	2.25			14.3		13.3		
Primary vegetable oils	2.07			13.2		12.3		
Paper drums	1.84	635.8		11.7		10.9		
Formaldehyde	1.78			11.3		10.5		
Cellulose esters & ethers	1.56			9.9		9.2		
Styrene	1.52			9.7		9.0		
Vulcanized fiber stock	1.50			9.5		8.9		
Rosin	1.39			8.8		8.2		
Fuels & purchased electric energy	1.34			8.5		7.9		
Phthalic anhydride	1.08			6.9		6.4		
Industrial ethyl alcohol	0.86			5.5		5.1		



A new problem for the steel industry, animal damage from fluorides emanating from a steel plant, required an extensive study beginning with basic determinations of fluoride quantity in materials and waste products.

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Industry in general, and the steel industry in particular, has for many years used gas cleaning equipment to separate entrained dusts from gases evolving from various thermal processes. Usually the collected material could be simply routed back into the processes involved. With increased understanding of air pollution problems, however, industry has found it necessary to consider treating and cleaning waste gases to control emanations of effluents found to be offensive to atmospheric cleanliness.

In January, 1951, the Geneva Works Mill of United States Steel Corporation became involved in problems of air pollution control when

members of the Utah State Agricultural College informed management of the Geneva Mill, located in Utah County, that animal damage had been discovered near the plant. Through careful examination, the damage was diagnosed as chronic fluorine poisoning. The management immediately started a program to determine the source and the quantity of fluorides emanating from its steelmaking processes and to determine the extent to which immediate corrective measures could be made at the sources.

The problem of fluoride detection, collection, and analysis was new to the steel industry and, therefore, it was necessary to develop basic pro-

cedures and standards by which the problem could be studied. Due to the technical aspects of such an air pollution problem, a force of engineers and agricultural and industrial research specialists were assembled to reduce to a safe level the fluorides emanation from the mill exhaust stacks.

It was assumed that the primary source of fluorides was from the open hearth shop, since fluorspar was used as a flux for shaping slag during the final stage of the heat cycle. Even before determinations could be made from stack-gas analysis, a search was made for a substitute material for fluorspar. Many materials and com-

continued



Figure 1. Smoke and fluorides from the giant open hearth furnaces (above left) have been eliminated at U.S. Steel's Geneva Works by use of electrostatic precipitators. Total cost—\$9 million.

Pollution control

continued

binations, such as bauxite, borax, mill scale, and fine ore were tried, but none were as effective as fluor spar.

Meanwhile, after consulting various air pollution experts, appropriate, acceptable standards for testing and analysis were developed and the program proceeded. A preliminary plant survey in March, 1951, indicated that the open hearth shop and sintering plant were the only major sources of contaminant that would require corrective measures. The survey also disclosed that the raw material responsible for the greatest quantity of fluorine was the iron ore mined from deposits in southern Utah, near Cedar City.

Following this initial survey, the services of Stanford Research Institute were obtained to conduct a complete in-plant balance of fluorides entering the plant in raw materials, leaving the processes in finished product or wastes, and being emitted to the atmosphere. At the same time, Geneva's Engineering Department concentrated on testing and evaluating various processes and types of gas cleaning equipment which might effectively clean the waste gases from the open hearth shop and the sintering plant.

Investigation had established that the only system known at that time for removing fluorides from waste gases was a wet-type scrubber. Therefore, the first attempt to test equipment for the application was the erection of a pilot plant scrubber. This

pilot plant, a 3,000 cu. ft./min. unit, was installed at the sintering plant since these emanations exceeded those from the open hearth. The equipment was used under various conditions of spray water pressure, spray arrangement, wash water recycle, controlled pH of wash water, and with various alkaline additives to the wash water. Test results failed to show that desired fluorine removal efficiencies could be attained by this method. In addition to the unsatisfactory fluorine removal, the tests proved that a once-through scrubbing system would require an excessive volume of water, which would have to be disposed of and would cause a stream pollution problem. The water recirculation tests introduced a serious corrosion problem, due to the low pH characteristics of the effluent. When alkalines were added to the water, deposits of calcium solids in the spray towers were so severe it was necessary to shut down the equipment at regular intervals for cleaning. The problems encountered in the wet scrubber soon led to the abolition of studies on a wet system.

Since the fluorides existed in the waste gas streams in both the gaseous and particulate state, application of the well-developed principles of dry dust separation was not a simple answer to the fluorine collection problem. There had to be an intermediate step in the gas cleaning process, the conversion of the gaseous fluorides to solids—a form which could be separated from the gas stream by dry methods.

The pilot plant equipment was, therefore, altered and expanded to include a dry-type electrostatic precipitator as the dust separation unit in the gas cleaning system. The unit was installed in series with an existing tower (previously used as the gas scrubber) to utilize the tower capacity for residence time for chemical reaction.

The fact that fluorine is found in nature combined with calcium, and that CaO is used to fix fluorides during analysis for fluorine, served as clues which ultimately led to the process adopted as the solution to Geneva's air pollution problem. The pilot plant work established that finely pulverized limestone or $\text{Ca}(\text{OH})_2$, injected and allowed to diffuse in the native gas stream, had an affinity for the gaseous fluorides present in the stream. It was also determined that a quantity (equal to approximately six times the theoretical amount) is required for satisfactory conversion of the gaseous fluorides since, in a dry

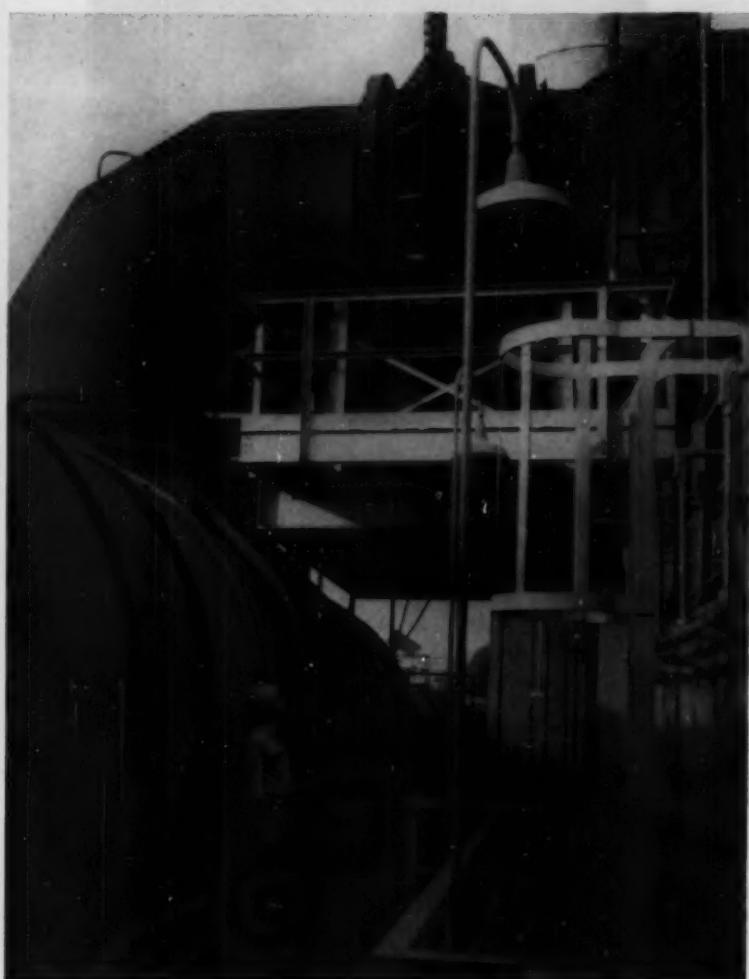


Figure 2. A giant collector main on top of the Geneva Works open hearth department gathers the smoke and gases, routes them to the precipitators for fluoride removal.

reaction, the rate of reaction is a function of surface area of the reactant.

On these basic determinations, full-scale facilities were designed to accumulate, treat, clean, and dispose of waste gases responsible for animal damage within the immediate area of the steel-producing facilities.

While the design work for waste-gas cleaning equipment was in progress, efforts to reduce the fluorine emission at the source continued. In a testing program to determine if a reduction could be realized by increasing the basicity of the sinter mix, it was found that limestone could be added to the mix at a rate as high as 6% by weight of the mix, without creating any serious problems in the sintering process. It was also found that at this maximum rate of addition, nearly half of the fluorides previously driven off during the sintering process was fixed in the product and, therefore, did not reach the atmosphere. The practice of adding limestone to the mix was immediately adopted and thus the first step in the reduction of fluoride emission was accomplished.

The limestone is added in the ore piles as they are stacked and blended in the ore bedding area. The added material is screened to 1/8 in. so it will take the course of the fine ore fraction. As the ore is reclaimed and screened, the limestone is mixed with the fine ore in a constant ratio and becomes an integral part of the sinter mix.

The corrective equipment provided by Research Cottrell consists of two identical, independent units designed to treat and clean the waste gases emanating from Geneva's two sintering machines. The treating and cleaning processes used in this full-scale application are similar to those studied in pilot plant work, with the exception of a waste-gas recycle principle.

An important feature of this principle is that the gases are sufficiently rich in oxygen to support combustion of the sintering fuel; therefore, about 40% of the fan discharge is recycled back over the sinter bed. This reduces the volume of gases requiring final treatment and cleaning, thus cutting by 40% the capacity of otherwise required equipment.

The final treatment and cleaning section of the system consists of facilities for furnishing and injecting pulverized limestone for final conversion, and the final dust-separation equipment comprised of a battery of mechanical cyclones and an electrostatic precipitator.

Limestone is reduced to a dust by ball mill pulverizers and is injected at

a rate of 30 lb./min. into the gas stream at a point just downstream from the recycle junction. This reactant material is pulverized to 80% passing a 200-mesh screen; therefore, maximum surface area is made available for exposure to, and absorption of, gaseous fluorides. After the reactant material has been introduced into the gas stream, the stream is directed to a treatment chamber designed to produce maximum contact between gaseous fluorides and the reactant limestone. Included in this chamber is a battery of 56 cyclone separators which separate the coarser dust particles from the gas stream prior to its entry into the electrostatic field. The cyclones also function as mixing devices which increase the exposure of fluorides to the reactant material surfaces. Dusts too fine for mechanical separation, are separated from the gas stream by the electrostatic precipitators, and the clean gases are allowed to enter the atmosphere through the exhaust stacks.



This was the first installation of its kind, and was the largest single electrical precipitator unit known to have been erected for collection of such material. It was expected, therefore (and confirmed) that certain difficulties would be encountered with some phases of the system. Despite these difficulties and the required adjustments, the equipment is fulfilling the function for which it was installed. This system is responsible for reducing emission of fluorides from this particular source by 96%.

While the gas cleaning equipment was being erected at the sintering plant, further studies were conducted at the open hearth shop. Again, an extensive program of process evaluation through pilot plant work established that a dry-type chemical reaction with high calcium-content material would be required. It was also determined that the final dust-separation equipment would have to be a highly efficient type of cleaner offering a relatively low resistance to the flow of waste gases. The equipment meeting these specifications was also an electrostatic precipitator.

The open hearth process is a variable process in itself. Even if steel of a consistent metallurgical specification were being produced day in and day out, over a long period, variables are introduced by the nature of the process and these variables must all be considered in the design of waste gas cleaning equipment. Generally speaking, these variables are: volumetric flow rates, dust or fume composition and concentration, particle size of the entrained dust, temperature and moisture content of the gas, and the concentration of fluorine in the waste gas.

The quantity of fume evolved from a furnace depends to a large degree on the condition of the furnace. The particulate loadings vary considerably during different stages of the heat. During the passage of the gases through the furnace, and then the flues to the boilers and stack, a considerable quantity of these particulates deposits out of the stream. To maintain efficiency, and to maintain the flue area, it is periodically necessary to clean by blowing with high pressure steam or air. This dislodges large quantities of dust which are emitted with the gases from the stack.

The greatest variable in volumetric flow rate is caused by the variable rate of fuel firing during a heat cycle. Another variable in volume is brought about by infiltration. When a furnace is rebuilt (usually about every three months), every effort is made to seal the brickwork to prevent infiltration of outside air. But this is accomplished with varied success, and during the furnace operation it is natural that conditions occur which increase the infiltration. It is these variables in the rate of flow, heat, moisture, and dust loading that cause the greatest engineering design problems.

As these variables were considered, it became evident that some arrangement of total collection, treating, and cleaning which would level out the variables would be desirable, both from a mechanical and economic point of view. It was evident from the outset that the economical approach was not to design a unit for each furnace. Geneva's open hearth shop was so constructed in relationship with other buildings that the space available for gas cleaning equipment precluded the use of individual installations. To adopt a multiple collection and distribution installation, it was necessary to conduct an extensive frequency study on all ten furnaces in the shop. The frequency study revealed that a definite statistical pattern could be established; considering

continued

Pollution control

continued

the ten-furnace shop as a whole, for normal operation, the following breakdown of heat stages could be made:

- 0.64 furnaces in the tap to start charge stage.
- 1.15 furnaces in the charging stage.
- 1.23 furnaces in the melt down stage.
- 0.29 furnaces in the hot metal addition stage.
- 3.82 furnaces in the ore and lime boil stage.
- 1.88 furnaces in the working stage.
- 0.22 furnaces being tapped.
- 0.78 furnaces in delay.

The period of delay includes those periods of furnace rebuild and repair and all delays of significance not normally included in the bottom or wall repair period immediately following the tapping of the furnace heat. This particular pattern resulted from the established shop practices.

Through an extensive testing and sampling program at Geneva, it was found that during the normal processing of a heat of approximately 250 tons of steel, the waste gas volumetric flow rate will vary from as low as 18,000 SCFM to as high as 60,000 SCFM per furnace. On the bases of average gas volumetric flow rates actually measured throughout the various stages of typical heats and of normal overlapping of stages of the heats for ten-furnace operation, the average total shop waste gas volumetric flow rate could be safely computed. Studies indicated a reasonable average shop-gas flow rate of 316,000 SCFM could be expected.

While it was possible to arrive at fairly accurate flow rates in the manner described, we believed at the time we were negotiating for gas cleaning equipment (and our experience confirmed) that it is highly desirable to engineer and design on the safe side. New developments and more efficient operations have resulted in greater production capacity so that it would not have been wise to place a limiting factor on this progressive trend toward greater production. Even though it appeared that Geneva's installation could be sized to accommodate a shop-flow rate of 316,000 SCFM, it was decided to size the installation to process a flow rate of 420,000 SCFM.

During the cycle of the heat the dust loading in the waste gas was found to vary from a concentration

as low as 0.1 grain/std. cu. ft. to as high as 2.0 grain/std. cu. ft. From determinations through hundreds of basic heats, the average shop dust concentration was determined to be 0.5 grain/std. cu. ft. Having been able to determine average variables, it was decided to collect and blend the waste gas effluent from all ten furnaces to supply a gas feed to the recovery portion of the system with a degree of uniformity necessary to maintain overall level performance.

Blending of waste gases is accomplished in a collector main flue, Figure 2, through which all the gases pass in their flow to the treatment units. The collector main is designed with baffles that promote the mixing and blending of gases, and control the distribution of the gases to the individual treatment units. It is also designed in area to maintain a velocity which will support the dust particles and prevent fall-out in the flue. The collector flue is installed just above the eaves of the open hearth building traversing the building from furnace No. 1 to No. 10. It varies in size from 7 ft. diam. at its smallest sections to 12 ft. 3 in. diam. in its largest sections. The gas enters the bottom of the collector flue through risers spaced at equal distances, as are the furnaces. The treatment units (eight in number), are placed in pairs and nestled between the existing buildings and stacks, Figure 3. Since there are ten furnaces and stacks and only eight precipitators, a small bleeder line is used to carry a portion of the discharge gas from the two end precipitators to the two end stacks.

The treatment units are physically identical but can be operated independent of one another. They are equipped with goggle valves at the inlets and outlets so any single unit can be isolated for maintenance. They are similar in arrangement to the units that were installed at the sintering plant. The basic differences between the two systems is the pressure under which they operate and the material used as a reactant. The open hearth units are exhausted by induced draft fans which place the treatment unit chambers under a negative pres-

sure. The material used for the chemical reaction is hydrated lime ($\text{Ca}(\text{OH})_2$) which has a higher available calcium content than the limestone used at the sintering plant.

The induced draft fans discharge the clean gases into the existing stacks where they are then exhausted to the atmosphere. Utilizing the existing stacks has several advantages. It alleviates the need for additional discharge stacks and the existing stacks are kept warm—important in the event that an emergency arises which dictates immediate by-passing of the cleaning system. If the stacks were allowed to cool and then receive an immediate charge of hot gas in an emergency, they would undergo a thermal shock which would cause extensive damage to stack linings.

Problems

Some practical engineering problems that were encountered in the installation of gas cleaning equipment on open hearths are worthy of note. One of the major problems encountered is that of handling the dust collected by the cleaning unit. Open hearth fume is composed primarily of particles below 5 microns in size. Analysis of a dust sample representative of a complete typical heat indicates the following size fractions:

Size Range	Per Cent of Total
+297 μ	0.0%
149 μ to 297 μ	0.1%
74 μ to 149 μ	1.2%
44 μ to 74 μ	8.5%
20 μ to 44 μ	0.9%
10 μ to 20 μ	2.7%
5 μ to 10 μ	4.5%
0 μ to 5 μ	82.2%

When it is realized that approximately 40 to 90 tons of the combined reactant and open hearth dust is collected from our ten-furnace shop in a 24-hr. period, it is evident that the disposal problem is one of major proportions. Furthermore, the dust collected is handled as waste material, since processes for extracting products of value have not been provided. Handling material of this composition is costly.

At Geneva's multiple installation the dust is removed from the precipitator hoppers by a pneumatic system which conveys the dust to two central points of storage. The dust is stored in elevated silos and as the silos fill, the dust is allowed to flow by gravity into a reject mixer, where it is combined with a sufficient quantity of





Figure 3. One pair of the electrostatic precipitators at the Geneva Works set between two open hearth stacks.



Figure 4. Control console under the furnaces controls the precipitators.

water to render it dustless. The material flows from the mill into a truck which carries it to the dump area for final disposal.

Another major problem is the control of moisture content in the gas. Moisture must be maintained sufficiently high to assure desired precipitator efficiency and yet not affect the collected dust to the extent that the material handling system will not function satisfactorily. The addition of required moisture cannot be accomplished by cold water sprays in the flue system without some deposition on the flue walls. It has been necessary to produce the proper moisture content in the gases using low pressure steam from our general plant system.

A third major problem is furnace pressure control. In an open hearth

furnace, the control of furnace pressure is extremely important. There is a very little margin between the operating temperature of a furnace and the maximum temperature the furnace refractories can withstand without failing. Any back pressure allowed to build up in the furnace would, in effect, block the normal flow of heat out of the furnace, and immediately elevate the temperature above the safe operating range. Therefore, it is important to provide an open hearth cleaning installation with properly sized fans and controls to regulate gas flow and system pressures to within extremely fine tolerances. For example, the pressure just below the roof of a furnace must not vary more than a few hundredths of an inch of water for any length of time or rapid deterioration of the roof refractories will occur.

Summary

To summarize, the equipment that has been installed and practices that have been instituted at our plant have successfully reduced the emission of fluorides to the desired low level. The systems which have been adopted to accomplish this control are very complex and require diligent operating attendance and monitoring to assure that their operating function is continuously maintained. We feel that the equipment erected at the Geneva Works is unique in that extremely large volumes of gas are continuously undergoing chemical treatment and final cleaning, while permitting the final collected product to be disposed of. Geneva Works has recognized its responsibility to the community and has met this responsibility with diligent action. This project has benefited the community by a vast improvement in the *general* air quality while accomplishing its specific objective of fluoride removal. The extremely high costs (almost \$9,000,000) associated with the research, initial equipment, and operating costs involved must be considered as a previously unrecognized cost of using Utah iron ore.

Presented at the A.I.Ch.E. Salt Lake City meeting, September 1958.

LICENSING

International licensing

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In this Part 2 of the International Licensing Feature a German engineer shows that the decision to take or grant a license is now one of time rather than principle, and centers on economic appraisal. Problems involve markets, anti-trust laws, taxes, and secrecy.

As a science, the principles, formulas and equations of chemistry are universal. However, the manners of the industrial application of chemistry, in other words; *chemical technology*, differ from each other in various countries. The reasons for such differences can hardly be compressed into a few words. I only wish to mention that differences in the raw material situation, in wages and social obligations, and in the level of the equipment industry lead to different approaches in solving the same technical problem. It is easy to visualize that, depending upon the country in which they operate, the international licensing of chemical technology involves problems both for the licensor and the licensee. Differences in the political and economic climate, the laws, the peculiarities of the respective markets, and the mentalities of the various nationals add to make the business of international licensing a difficult job.

American companies also encounter many of our problems in their license agreements. In the event they intensify their licensing operations with the Eastern hemisphere, other problems may arise.

Everybody looks at a problem from his own particular viewpoint. I am a European working in one of the largest chemical companies that is active in many branches of the industry in nearly every country of the world. Thus,

I will expand on the problem of international licensing as a European sees it and more particularly, as a German industrialist. I will explain the problems we experience in both hemispheres of our divided world. I will first explain the general principles guiding us in licensing. That, taking into consideration the economic, legal and technical difficulties, I will subdivide the subject into the licensing of patents and of chemical technology.

General considerations

The first problem arising from a possible license arrangement is the question: "Should we grant a license or should we keep our knowledge secret?" The European chemical industry was once (though rather long ago) number one in the world. In those days, its managers thought it best to defend their dominating position by keeping secret the special technical knowledge of their companies and to communicate it only to their foreign subsidiaries, which were mostly wholly-owned. However, through the results of two world wars, many of these subsidiaries passed into other hands. Moreover, both the level of technical education, as well as the appearance of new independent engineering companies, have made substantial contributions to the postwar evolution of chemical industry. Many techniques then became accessible to everyone, and, as these lost their pro-

prietary value, the management of chemical companies reoriented their policies.

During the last world war, Germany and the European countries under German occupation were cut off from the rest of the world. After the war, the chemical industry in these countries had to seek new contacts with chemical companies in other countries (especially in America) where important discoveries, for instance in the field of antibiotics and petrochemistry, had been made.

Consequently, the present managers of the European chemical industry now realize that new technical developments cannot be monopolized for a long time, particularly, when there is no adequate international patent protection possible. They, therefore, have changed their attitude and decided to share the new techniques of their companies by licensing certain processes, thereby collecting royalties or other remunerations. The Haber-Bosch ammonia synthesis is a typical example. It was already extensively licensed after the first world war. To some extent, the same holds true for several manufacturing processes for basic chemicals, such as: phthalic anhydride, phenol and caprolactam, which were licensed after the second world war. Many licenses in the antibiotics and petrochemical fields were also "taken" from American licensors by European chemical companies.

This mutual exchange stimulated research on both sides of the Atlantic and helped to save much time which would otherwise have been spent on new projects. Hence, the decision of the management of a European chemical company whether to grant a license or not, or whether to take a license or not, is today more one of time than of principle.

In this respect, my own company decided to buy the know-how and the engineering for ethylene oxide and synthetic ethanol. We had done extensive research on both subjects, and had even built pilot plants. However, we found that taking out a license proved to be more economical, because we could concentrate our engineering forces on other subjects.

Furthermore, to safeguard the interests of the national economy, the export of so-called "intellectual property" is subject to approval by certain European governments. The governmental officials understand this new trend and in nearly all cases, except where military considerations intervene, approve proposed licensing operations both with western or eastern partners.

Licensing a foreign company, or even a foreign subsidiary, means as-

sisting the licensee to compete with the licensor. The decision to license or not, therefore, boils down to an economic appraisal. In other words, will the overall assets more than compensate for the reduction in sales?

This question brings up the most important point arising from possible license agreements: To what extent can international licensing affect our foreign markets? How do we attempt to resolve these problems?

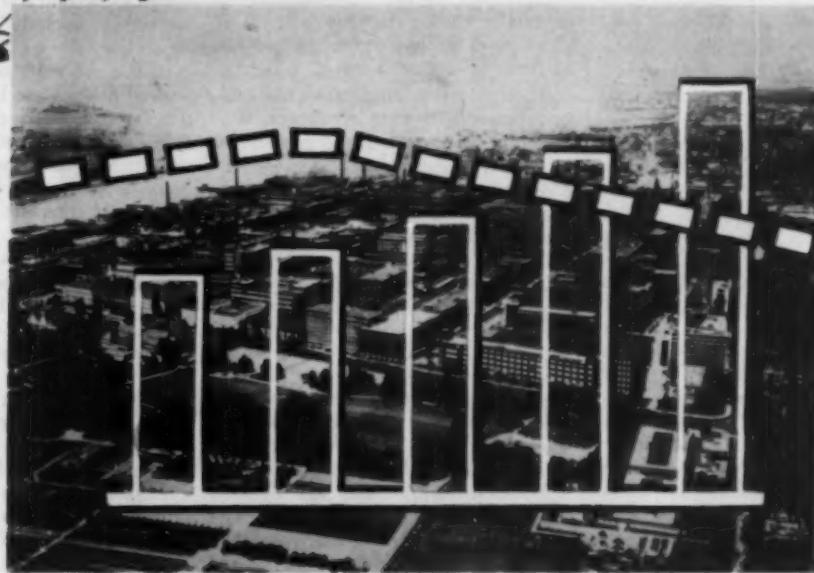
As you know, the markets in the individual European countries, being rather small compared to those of America or Soviet Russia, the success of a European chemical company depends, in general, much more on exports than does that of an American company. While the American chemical industry exported only 6.3% of its production in 1957, the corresponding export rate of the German chemical industry as a whole was 23.2%, that of Great Britain 21.2%, and that of the Netherlands 49.6%. The export figures of the three largest German chemical companies are substantially higher than the average, and in 1957 amounted to 32% for Farbwerke Hoechst A.G., 38% for Badische Anilin- & Soda-Fabrik A.G., and 41% for Farbenfabriken Bayer A.G., compared to 8% for DuPont, 7% for Union Carbide, and

15% for American Cyanamid. Thus, much more than the American counterpart, the European chemical industry must weigh to what extent licenses on know-how and patents, granted to a foreign company, will impair their exports. They will, if possible, try to limit the territorial scope of the license and rely (in this respect) on their patent position. In most situations, the least they can, and will, do is not grant licenses on patents in countries to which they do not want the licensee to export. They may often go farther: A patent conveys to the owner the right to exclude others from selling the patented product (or the product made by a patented process) not only in the country in which the patent has been granted, but also to export that product, to another country in which the patent has not been granted. The owner may therefore, renounce his exclusive selling rights in that country, but keep the right to prevent from selling abroad. In this way the licensor not only prevents his licensee from exporting to other foreign countries in which the licensor holds corresponding patents, but also to countries in which he has none. For example: A French company grants to a German company a license under a German

continued



Licensing a foreign company means assisting the licensee to compete with the licensor. If the licensor sells abroad he is therefore in competition with himself and the decision to license or not boils down to the economic question of whether overall assets will more than compensate for reduction in sales.



Expanded Assets

Reduced Sales

Licensing

continued

manufacturing patent for the manufacture, use, and sale of a given chemical in Germany only. This prevents the German licensee from exporting, not only to France and Great Britain where the licensor holds corresponding patents, but also, for instance, to Egypt and Yugoslavia, where the licensor did not apply for patent protection, but where he is selling. Often, such a restricted license is not attractive enough to the licensee. In most cases (for export purposes) the patent owner, at least, will then agree to the so-called "incidental use" of the patented product. If, for example, the patent license granted by the above French company relates to a lacquer composition for electric insulation, the licensor will not object to the export from Germany, (to Egypt or even to France) of automobiles in which this lacquer has been used for the ignition system. He may go further and grant export rights to such countries where little harm to his own export interests is expected. On the other hand, if his patent position is weak, and mainly the sale of know-how is involved, he will at least try to limit the use of the know-how to the country of the licensee. In agreements with countries of the Communist block, where no patent protection is possible, the European licensor may (to protect his own sales in other countries) insist on an obligation not to export the licensed products.

Each case has to be investigated in the light of the anti-trust laws which are in force, both in the countries of the licensor and the licensee. Though many European countries have promulgated laws tending to avoid a restraint of trade in their own country, the laws are rather liberal for contracts whose economic center of gravity lies abroad. However, when the laws of the licensee's country are much less liberal (often the case of the anti-trust laws in the United States) only part of the wishes can be obtained.

An important part of the exports of European chemical factories goes to other parts of Europe. For instance, in the case of Bayer, in 1957, the European exports accounted for 53% of the total foreign sales. As a rule, therefore, a European chemical company will be much more reluctant to license another European company than a company operating outside of Europe. As the European Common Market grows, this tendency will probably become even stronger. If the

financial resources permit a big company (lacking adequate facilities or cheap raw materials, and realizing the need for another production center within the Common Market) will prefer to place such a new production unit into a European subsidiary company controlled by itself. It is, however, to be expected that (as in America) any monopoly formation, through excessive concentration of economic power, will be prohibited by the stringent anti-trust provisions contained in the Treaty of Rome, relating to the formation of the European Economic Community. However, these practical implementations will still take some time to be effective.

Countries, with unfavorable balances of payment and soft currencies, restrict the imports of certain products. Consequently, in such a country the exporter finds it impossible to support a sales organization and a customer's service for these products. The question is then: "Should we make these products through a subsidiary, or should we license somebody?" Because the parent company has to invest in hard currency and may only get soft currency in return, making the product through a subsidiary is often not a good solution. Instead of a mere license, a European chemical company may also consider the possibility of combining with the licensee the right to purchase a certain quota of the licensee's production at a preferential price. Selling this quota through the licensor's own sales organization in competition with the licensee avoids a reduction of the licensor's product line in that country. By drawing on an indigenous production, the sales organization is given valuable backing, especially during periods when (for shortage of foreign currency) imports, in general, are curtailed.

Though every big European chemical company is keen to export, it is reluctant to base its home production too much on exports to non-controlled companies, especially in cases where a very substantial part of such exports is absorbed by only one or two foreign countries. Substantial exports of a specified product make it generally attractive to manufacture the product in the importing country. The resulting loss may reduce the degree of exploitation of the production plant to such an extent that the profitability calculation turns from black to red. Therefore (for a long time as a rule) a European chemical company will not try to supply the needs for a specific product in America or Soviet Russia, if these needs reach a figure which is high in proportion to the

needs of other countries. In such a case it prefers to grant a manufacturing license.

Considerations applying to the international licensing of patents

The foregoing considerations being of a general nature, I will now refer to problems specifically related to the international licensing of patents. Licensing of patents is possible only in countries in which patents covering a monopoly or privilege to the owner to manufacture, use, and sell a certain commodity are granted. This is not so in countries under the communist regime. Hence, the following considerations apply only to the Free World.

In filing foreign patent applications, a chemical manufacturer's first aim is to prevent a foreign country from producing the same product, or from importing it into the country in which the application has been filed in competition with the owner of the patent. Filing in view of licensing to a third company is a rather exceptional case. When a European company, by licensing its patent to a competitor in a foreign country, partly gives up its export monopoly, it may be more interested in the possibility of obtaining similar rights in another field from the licensee than in royalty fees. A big foreign company is generally preferred because the possibility of obtaining licenses in return is greater, than from a correspondingly small company. Contracts providing for an exchange of patent and know-how licenses, whose value compensates for each other, are particularly attractive. As in such contracts financial considerations are excluded, the tax situation is favorable.

Since the costs of filing and prosecuting patents are high, the European chemical industry does not file in all the countries to which it exports its products. I mentioned before how it may try, nevertheless, to safeguard its export interests. In many cases it will file only in the industrialized countries, with a view of preventing the resident competing chemical industry from manufacturing the same product and from disturbing its market by exports. Its export interest in the industrialized country itself is, however, often small. Exports to Japan, of a given pesticide made by a European firm may, for instance, be small and would, by themselves, not justify building up a patent structure there. Nevertheless, to prevent its Japanese competitors from exporting, say, to Latin America, India, and Red

China, the European company may file patents in Japan. In such a case the European company might not only grant a license to manufacture, use, and sell the pesticide in Japan, but would make the license more attractive by allowing exports to certain surrounding countries. For instance, in Formosa or Korea, the European company may not have its own export organization.

From what was said before you will understand that a European chemical manufacturer is, in general, reluctant to grant an exclusive license to a foreign company, thereby depriving himself of export rights. On the other hand, as the individual European markets are relatively small, a European

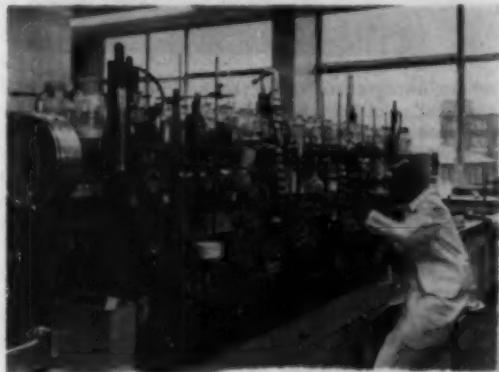
company receiving a foreign license will often insist upon exclusive rights, at least in its own country.

Problems in international licensing of chemical technology

Free world. The problems in licensing chemical technology, often coupled with the licensing of patents, are complex: Western Europe plays an important role both as licensor and as licensee in the exchange of chemical technology in the Free World. This exchange is particularly intense between Europe and the United States. The fundamental theory is often pro-

duced in Europe, but its large scale technological applications are developed in America. In the past years, Western Europe has acquired from the United States, *inter alia*, petro-chemical processes for the manufacture of butadiene, synthetic rubbers and ethylene oxide while the United States have acquired licenses from Europe in the field of polyolefines, urethane, polyamide plastics and the respective intermediates. Since the last war Latin America, especially Brazil and Argentina, has benefited from European chemical technology, while Japan and India are keenly interested.

The general pattern of international license contracts on patents and/or know-how, between European chemical firms in the Western hemisphere is very much like that made between American companies. However, in each contract the currency regulations valid for the licensor and the licensee have to be taken into account. This is especially important when the licensee is obligated to pay royalties over an extended period. It may hap-



"... fundamental theory is often developed in Europe, but its large scale applications are developed in America." (Below) 100,000 amp. Uhde mercury cells in an American chlorine plant.

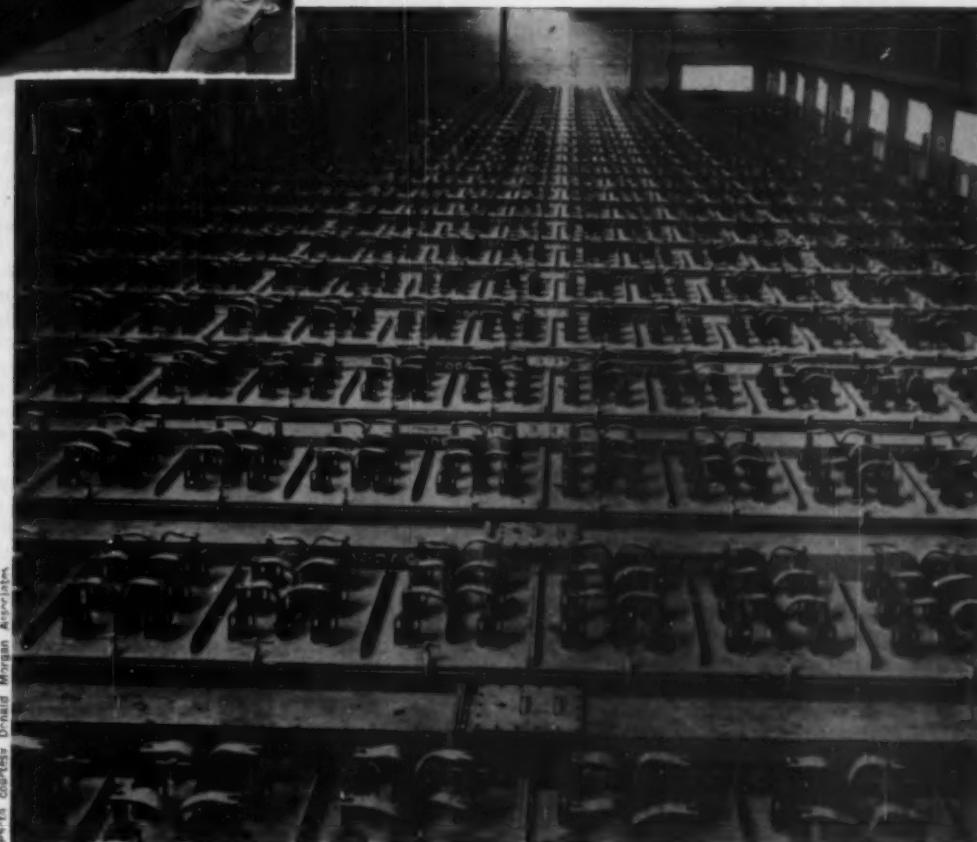


Photo courtesy: Donald Mullan Associates

Licensing

continued

pen that, through a change of the currency regulations in his own country, the licensee will no longer be in a position to transfer the payment of royalties. The licensor may then receive, for instance, some rapidly devaluating Pesos or Cruzeiros, that must be spent in the licensee's country. In countries with an unstable currency, it is often better to receive a lump sum in hard dollars during the early stages of the contract than to hope for a large royalty income in the future. The currency aspect becomes still more important when, as is often the case, not only technology, but also equipment is to be supplied. As economically weak countries buy on credit (at present certain countries ask for seven years) one needs the backing of a bank and/or an insurance company to avoid losing one's shirt.

The question of taxes levied on revenue in the licensee's country is to be investigated in every case. If there is a treaty avoiding double taxation between the countries of the two parties, the licensor will only have to pay taxes in one country, either in his own country or in that of the licensee. If, on the other hand, there is no treaty, he may be in the lucky position, as in the case of America or Germany, to be able to deduct the taxes in the licensee's country from the taxes he has to pay in his own country. In such a case, the tax to be paid in the licensee's country is only of importance to the licensor, if and to the extent it is higher than the income tax due in the country of the licensor. If the licensor has, however, to pay a tax on his license income abroad as well as in his own country, licensing loses much of its attractiveness. If the license contract provides for royalty payments running for a considerable period of time, there is also the risk that the Government of the licensee's country may increase the tax rate due on the income of foreigners. And, if this government has to watch its balance of payments closely, it may not honor a clause in the contract providing for the payment of income taxes by the licensee. Concerning the normal secrecy clause, there may be an argument as to how long, after the expiration of the license agreement, or the date of transfer of the know-how, the contents must be kept secret by the licensee. Previously many European chemical companies, especially when granting know-how, liked to make such obligations *sine die*. Now they realize the necessity of limiting this time to a well defined



Photo courtesy Donald Norgen Associates

In soft-currency countries, where imports are restricted and revenues from a subsidiary are unattractive, the best solution may be licensing. (Above) A Perlon (German nylon) plant of Inquitex S.A. built in Andoain, Guituzko, Spain under license from Friedrich Uhde, G.m.b.H., Dortmund, West Germany.

period. In fact, they want to have this provision in a contract in which they are the licensee.

Sometimes the question of the law to be applied in the settlement of disputes is more controversial. It is understandable that each party wishes to take recourse to the law of its own country (with which it is familiar), especially if it is the licensor. In a license contract, the rights and obligations should, however, be so well balanced that there is no preponderance of one party over the other. In my opinion both parties should therefore agree upon bowing to a neutral authority, such as an arbitration court. This court, founded on the rules of arbitration and conciliation of the International Chamber of Commerce, should then decide which law it sees fit to apply. Another equitable solution is to omit any provisions relating to the settlement of disputes and litigation from the contract. This omission gives each party the possibility of suing the other party where it wants.

The transplanting of European chemical technology to countries that have not yet acquired a noticeable degree of industrialization presents no difficulties of special significance. The equipment, perhaps with the exception of certain items, is bought in Europe and assembled abroad. However, using unskilled, indigenous labor and inadequate machine shops for the assembling and starting up of the plant makes it a difficult job to fulfill

guarantees. The problems begin when the country of the licensee has its own equipment and instrument industry. In such cases, because spare parts and customer's service are more readily available, and sometimes because of governmental impositions, the licensee must use equipment that can be bought in his country.

Before signing a license contract, the licensee needs to know the cost of the plant and the expected return on his capital. Because of the difference in the wage and raw material scale between Europe and, for instance, the United States, equipment, assembly, and processing costs cannot be calculated by simply converting the European prices into dollars at the official rate of exchange. As a first approximation, it is generally sufficient to apply a divisor resulting from the comparison of the prices of several chemical plants in America and, for instance, in Germany. As far as chemical equipment is concerned, this divisor relating the purchasing power of the dollar to the DM is in the order of 2.6 to 2.8. This means that comparable assembled equipment amounting to 2.6 to 2.8 million DM will cost approximately \$1 million if bought and assembled in the United States. This divisor applies *mutatis mutandis* also to other European equipment prices. For larger plants, or, in cases where by applying this divisor the calculated profitability of the projected plant appears to be doubtful, such an approximation is hardly acceptable.

An exact cost estimate can only be made by determining the price of each piece of equipment, item by item. Before a firm license contract has been signed, the licensor possessing the know-how is, of course, reluctant to give away a complete list of the machinery indicating sizes, construction materials and performance data. Therefore, unless the pending deal is important enough to have such estimating done in the licensee's country, by an engineering firm enjoying the confidence of both parties, the negotiations often reach a deadlock.

The use of equipment made in the licensee's country for a plant designed according to standards employed by the licensor involves certain risks. When examining the suitability of machinery designed in the licensee's country, the licensor has to rely on certain performance data supplied by the machine manufacturer. He rarely is able to test these machines in his own plant. Equipment size standards are often different in the two countries. When one reaches an "in between" range, with the use of foreign-made equipment, this difference may cause difficulties.

The differences in measuring systems are a permanent nuisance. Adapting drawings made, for instance, in France or Germany to the American measuring system, or vice versa, requires redrafting, which is an appreciable item in the total design cost. Recently my company bought plans and drawings designed for a Canadian plant. Adaptation to the metric system, and especially to the German way of building chemical plants, required 110,000 man-hours; the total erection cost of that plant was in the order of DM 40 to 45 millions. Three percent of this amount had to be spent for the adaptation of the drawings. The engineering expenses for the Canadian plant amounted to six percent of the total cost of the erected plant.

Soviet bloc countries. Chemical technology has become an interesting commodity in Western Europe's trade relations with the communist dominated countries. As there is a lack of patent laws in the Western sense, these countries are free to exploit the subject matter of all foreign patents and other scientific and technological publications which they collect, abstract, and circulate by a well organized system among their competent staff. However, they often lack the time and the qualified personnel to develop the best processing methods. So they purchase the technology. As their own equipment industry is not yet very specialized in the chemical field, or is overburdened with orders,

they also buy most of the necessary equipment.

In license contracts with communist countries, royalty payments related to actual production are practically out of the question. A communist government will hardly accept revealing its actual production and having it checked by a neutral auditor.

As a consequence of the lack of patent protection in these countries, the European licensor may try, by contractual obligations, to prevent or limit the exports of the products manufactured behind the Iron Curtain. Another problem is the preventing of illicit imitation of the equipment supplied, or of illicit reuse of the plans and drawings for other plants. Though the licensee may accept a contractual obligation forbidding the illicit reuse in one or the other case, the risk remains (particularly regarding the drawings) that such a provision may not be enforced.

In these countries the notion of *trade secrets* has a different meaning than in the West. In the Free World, whose economic philosophy is based on competition between private enterprise, every company tries to keep secret its special processes and tricks vis-a-vis third parties. In a communist dominated country, there is no important private industry; there is but one employer: the Government. There is no trade secret between the factories; on the contrary, there is an exchange of information to attain the maximum efficiency. It would be against the economic philosophy of these countries for one of their state-owned companies to accept a license contract containing a clause obligating it to keep the know-how received secret from persons not employed by the company. The maximum protection attainable is to obligate the licensee not to disclose to foreign nationals the know-how obtained. The risk of a leakage is obvious.

It is logical that these risks are considered in the price of the know-how. However, as a communist licensee resents being discriminated against, he will not accept a price substantially higher than that paid by a Western buyer.

The wording of the *force majeure* clause in a license contract between parties of Western democracies, is so standardized that it is hardly read through before signing the agreement. In a contract with a communist partner this clause may be of utmost importance. Of course, "Acts of God" do not occur in a communist country! Since a private company in Western countries cannot be held responsible for the acts of its Government, on

which it has no control, "Acts of Government are generally considered as a force majeure". A Soviet arbitration court has also held that acts of the Soviet Government are to be considered as "force majeure". In such a case, since for all practical purposes, the Soviet Government and its 100-percent owned company are identical, this formal approach is an injustice to the other party. If the Government or the company does not want to fulfill the contract, the Government orders the company not to fulfill it, and consequently the licensor is entirely at the mercy of the Soviet Government. In addition, since a strike in their ideology, is a legitimate defense of the working class against exploitation by the capitalists, a communist partner will also refuse to regard a strike as a case of "force majeure". This is very important if the Western partner has to agree to supply know-how and equipment within a fixed time, infringement of which entails fines or cancellation of the contract. In recent negotiations, the Russians offered the choice of limiting "force majeure" to three events: earthquake, fire and flood, or (in case of dispute) to allow the interpretation of a competent ordinary or arbitration court.

Though the wording of a "force majeure" clause is particularly important in license contracts with communist countries, I would also recommend particular attention to this clause in such international license contracts made with parties having their legal domicile in a country with strong socialistic or dictatorial tendencies.

Normally, there is the possibility of submitting the settlement of disputes to an arbitration court. Russian arbitration courts have rendered some objective judgements. But, no one should forget that a national of a communist country is (practically) not free to render a decision against the political or economical interests of his country. Soviet Russia has, in many cases, also accepted a ruling by a foreign arbitration court. At present, they prefer a court at Stockholm, which decides according to the letter of the agreement and the principles of the law of collisions.

You will note that I was not in a position to indicate all the problems arising in international licensing. Therefore I limited remarks to certain hints and could not go into details. Nevertheless, I hope that one or the other aspect has been of interest.

Presented at the A.I.Ch.E. Kansas City meeting, May 1959.

PROCESS CONTROL

Continuous distillation plant Controls

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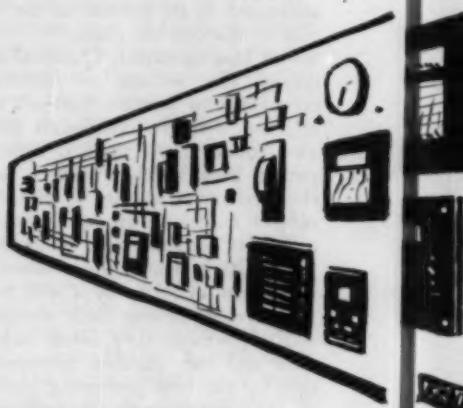
The importance of regarding a distillation plant as an energy balancing system, showing that when top and bottom products of high purity are required from a single column, the energy balance is the critical factor. Also—three rules for setting up the control system for a distillation plant.

Setting up the control system for a distillation plant is a chemical engineering problem rather than one in instrumentation. A continuous distillation plant is designed to produce top and bottom products within a given specification, from a feed of known composition. Provided adequate data are available, the designer can calculate the required reflux ratio, number of theoretical plates, position of the feed plate, and the necessary heat input to the reboiler and the heat removal at the condenser. This is the static design stage—a paper study of the problem assuming that all compositions, temperatures, flow rates etc., remain constant. The static design does not give a complete picture of the distillation process under works conditions where variations in flow rates, temperatures, etc., are continuously imposed due to the limitation of commercial instruments. It is, for example, quite impossible to provide a constant feed to a distillation plant; the flow will vary to a degree dependent upon the accuracy of the instrument used to control it. In addition, external changes such as steam pressure fluctuations in a factory network are continuously occurring, and these fluctuations would affect a steam heated reboiler.

A distillation plant is in fact an energy balancing system which is subjected to continuous variations, each of which tends to disturb the balance.

A composition gradient, or pattern, exists in a distillation column, and for

any given feed condition the profile and position of this pattern depend mainly upon an energy or dynamic balance between the heat input to the reboiler, and the heat removed at the condenser. The purity of the top and the bottom products also depends upon the position of the composition pattern. It is evident that due to the variations which are continuously imposed on the plant, the energy balance will be disturbed, the composition pattern will "float" in the column, and consequently the composition of top and bottom products will vary continuously. It is, therefore, impossible to continuously produce materials of a precise purity from a distillation



column operating under works conditions.

Some allowance in the design is necessary to permit the pattern to float. A control system is required to deal with disturbances and restore the energy balance to the value intended by the designer. To ensure that the column does not produce material below the minimum specified purity, it is necessary to assess the relative importance of the variations. So many variations can occur together, and at random, that it is difficult to consider their combined effects. In this paper an attempt is made to assess their relative importance by considering each one as a separate static change and estimating the necessary allowance. The time factor is outside the scope of the article, but rules are given for setting up the control system to ensure that the distillation process is properly controlled in accordance with the energy balance concept.

Principles underlying the control of distillation processes

Chemical composition is the property which demands a particular dis-

tillation process, but in the present state of knowledge it is not possible to measure it with sufficient speed and accuracy, so that the information can be used continuously in a control system. Therefore, some secondary property such as temperature, which is related to composition, is usually measured. A further complication arises because a distillation unit consists, essentially, of three parts; the reboiler, the column, and the condensing system. For satisfactory control of the process, these three parts must operate in energy or dynamic balance in the way intended by the designer. The importance of the process variables was recognized by Gilliland & Reed (1), and a further development appeared in a paper by Perry (2). Later, Ruhemann (3) specified certain conditions for controlling a low temperature distillation process and postulated arrangements of the controllers to maintain this balance.

General principles have not, however, been formulated in the literature in a simple manner to guide designers in setting up suitable control systems

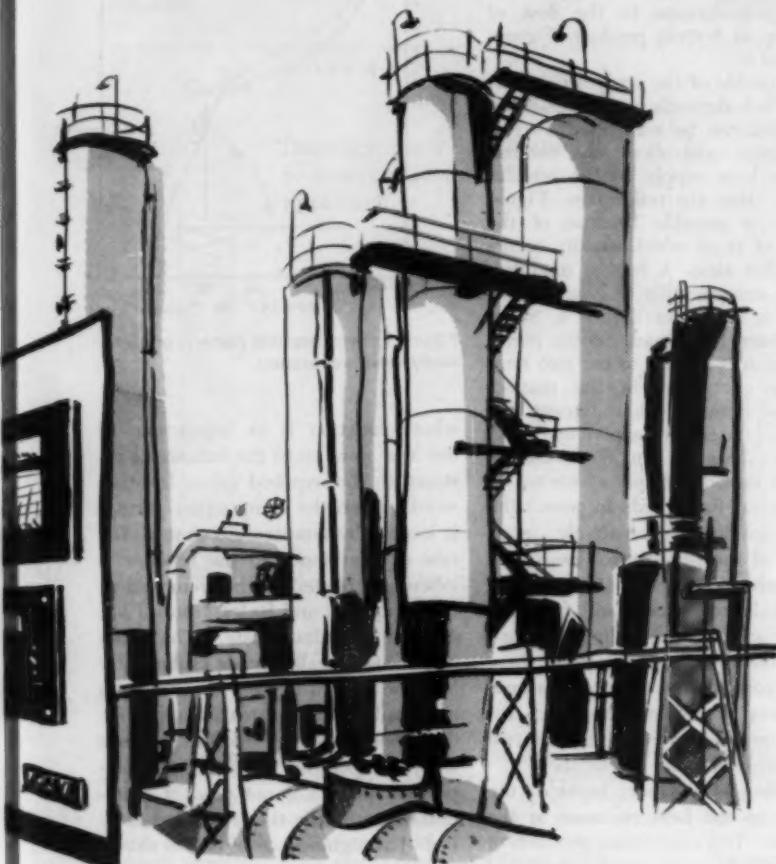
for the different cases which arise in industry. One of the main reasons for this is that the significance of the word "constant" as applied to a distillation control problem is not often appreciated, especially in its relation to the balance which must be maintained between the reflux and reboil systems when the plant is operating under works conditions. If, for example, due to an external disturbance, the steam supply to a reboiler is forced to a slight excess above that required to maintain the desired heat balance with the condensing system, there will be a tendency to increase the concentration of the heavier components in the upper portion of the column. In the absence of corrective action from a control system, this drift may continue, particularly if the next change imposed on the process is in the same direction, such as a decrease in feed rate or supply of coolant to the condenser. The purity of the top product can, therefore, deteriorate even though the number of plates and reflux ratio are adequate under the constant conditions assumed in the static design.

The importance of keeping the distillation process balanced is a concept not readily accepted by designers, because the usual approach to the subject is through a study of binary mixtures in which the enthalpy of the components at any point in the column is linked to the heat supplied at the reboiler and that removed at the condenser by simple flow ratios, based on the assumption of constant molar overflow, or constant molar enthalpy throughout the system. The fact that a still is an energy balancing system is largely obscured by the convenience and simplicity of methods embodying these ratios as a basis for designing the column. The energy or dynamic balance concept is therefore often completely ignored, although it is of paramount importance in designing a distillation plant which will not fail to produce the desired products when subjected to normal process variations. This aspect is discussed in greater detail by Harbert (4).

From an examination of the various factors involved, it is considered that the principles to be observed in setting up the control system for a distillation process can be reduced to three simple rules:

1. Control or regulate the position of the composition pattern inside the column.
2. Maintain the desired reflux or reboil ratio whatever the throughput of the column, with-

continued



Distillation

continued

in its designed capacity.

3. Relate the rate of heat input at the reboiler to the rate of heat removal at the condenser.

These rules are generally applicable as they are concerned with the distillation process itself, and are independent of the internal design of the column, number of components, type of instrument, etc. Compliance with these rules will ensure that the control system will deal with variations in such a way that the distillation process always moves towards the balance intended by the designer. The means adopted to satisfy the rules determines the way in which the plant will respond to the variations imposed upon it. Automatic control is assumed in this paper, but the same principles apply when a plant is on manual control.

Methods of satisfying the rules

1—Controlling the position of the composition pattern.

a. Controlling the temperature at some point in the column will control the position of the composition pattern, since temperature and composition are related at a given operating pressure. Temperature patterns at various reflux ratios can be drawn similar to Figure 1 and will indicate the sensitive zone. Thus, the divergence of the lines in Figure 1 indicates that the maximum variation of temperature, at a given position in the column, occurs at 80 and 94°C. Temperature-difference measurement, a modification of this method, is particularly suitable for vacuum distillation where a single temperature may be seriously affected by the pressure at the impulse point which changes with the load on the column. It is also important to ensure that the temperature difference between the impulse points due to composition change is substantially greater than that due to pressure drop, otherwise a false signal will be obtained.

When the temperature pattern shows little change of slope, temperature control can still be used by employing vapor pressure bulbs filled with liquid of the required composition at the impulse point.

b. Take off as top or bottom product, a controlled fraction of the feed, Figures 5, 8, and 9.

c. Control to a fixed ratio the rate of

withdrawal of top and bottom products, Figure 2.

Methods b and c depend upon the fact that only one position of the pattern will satisfy the material balance fixed by the relative flow rates. They cannot be used where high purity products are produced, because a change in purity sufficient to throw the material "off specification" would result in such a small change in flow rate that a standard commercial instrument would not detect it.

2—The maintenance of either a fixed reboil or reflux ratio for all throughputs.

a. A fixed reflux ratio can be achieved by controlling the flow of reflux proportionate to the flow of top product, bottom product, or feed. The first method is most common, using a splitter box (reflux divider).

When using a partial condenser, the controlled relation is between the heat load and any one of the above flows. In certain stripper stills a reflux condenser is unnecessary, as the feed entering at the top of the column is the reflux and Rule 2 is automatically satisfied.

b. A fixed reboil ratio can be obtained by controlling the heat load on the reboiler proportionate to the flow of feed, top or bottom product, Figures 7, 8, and 9.

c. The profile of the composition pattern, which depends on the reflux/reboil ratio, can be controlled by two temperature controllers, one controlling the heat supply to the reboiler and the other the reflux flow, Figure 3. This is possible because of the change of slope which usually occurs with reflux ratio. A further modification for stripper stills (e.g. ammonia/water) is shown in Figure 4. Statements have been made in the literature that it is unwise to use two temperature controllers in the manner described above. Such statements are probably based on experience with columns designed on the basis of *constant conditions* and where no allowance has been made to permit the pattern to float. Alternatively, interference of the two control loops may have been responsible. On the *dynamic balance concept* and from the point of view of controlling the position of the composition pattern, there is no reason why two temperature controllers should not be used, for the pattern will move until the two temperature settings are satisfied.

3—Relating of the heat input at the reboiler to the heat removed at the condenser. Top and bottom products of the specified purity can be produced

only when a definite relationship exists between the rate of heat input at the reboiler and that removed at the condenser, since the profile and position of the temperature pattern depend on a dynamic balance between the two. Any lack of balance caused by superimposed variations during operation will cause the pattern to move up or down, if not restrained, until sufficient change in composition and flow rate of the top and bottom products has occurred to establish a new dynamic balance to satisfy the superimposed change. When the temperature at a point in the column is controlled, corrective action is taken by the controller,

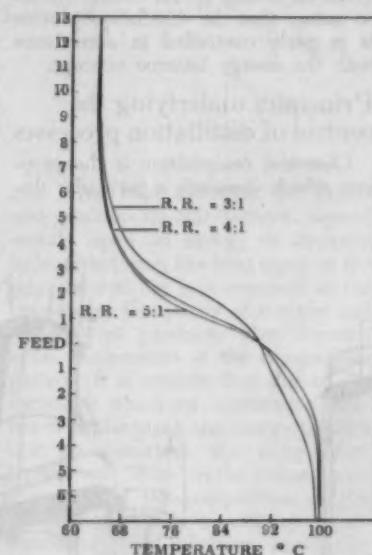


Figure 1. Temperature pattern of methanol/water separation.

whose function is to adjust one of the heat flows until the balance is restored to the required value. In other words, when the composition pattern is located by temperature control, the rate of heat input to the reboiler is inherently related to that removed at the condenser and Rules 1 and 3 are satisfied simultaneously. The condenser is usually made sufficiently large so that it is able to deal with any load up to the maximum which the reboiler imposes upon it. In cases where temperature control of the composition pattern is not used, it is important to ensure that Rule 3 is satisfied. The significance of this is shown

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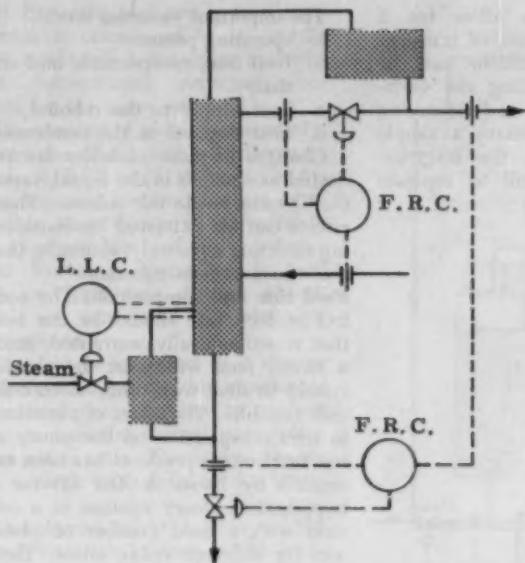


Figure 2. (a) Composition pattern positioned by maintaining a definite ratio between rates of removal of top and bottom products by fixed ratio controllers (F. R. C.). (b) Reflux rate related to feed. (c) Reboil rate related to reflux rate by liquid level controller (L. L. C.) which ensures that liquid reaching bottom of column, and not removed as bottom product, is reboiled.

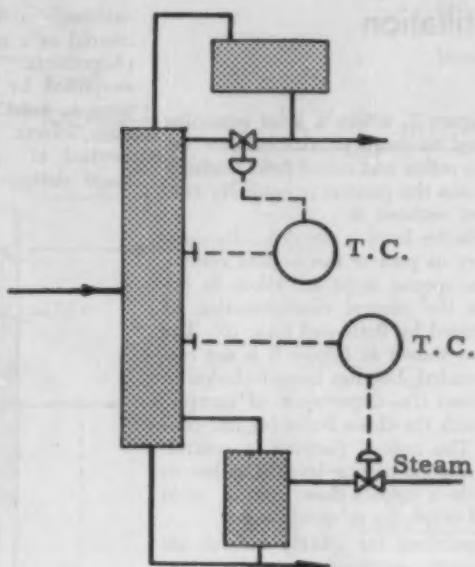


Figure 3. (a) Temp. pattern positioned by control of temperature at two points in the column. (b) Reboil rate related to throughput by controlling the slope of the temperature pattern which depends on the relative settings of the two controllers. (c) Reflux rate related to reboil rate by the two temperature controllers since a stable position of the pattern depends on a dynamic balance between the two.

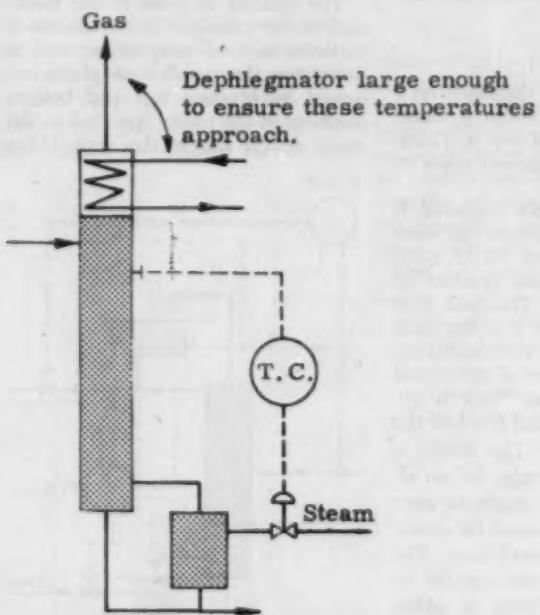


Figure 4. (a) Composition pattern positioned by the gas outlet temp. from the dephlegmator (practically equal to cooling water inlet temp.) (b) Reboil rate related to throughput by controlling the slope of comp./temp. pattern by the gas outlet temp. from dephlegmator and the controlled temp. at a point in the column. (c) Reflux rate related to reboil rate by temp. controller since stable position of temp. pattern depends on dynamic balance between the two.

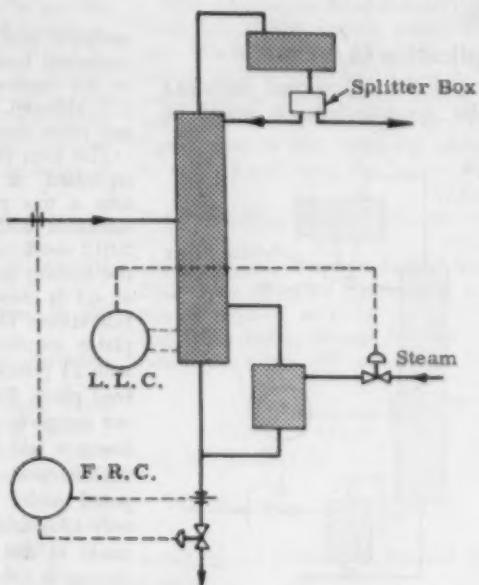


Figure 5. (a) Composition pattern positioned by taking off as bottom product a controlled fraction of feed flow. (b) Reflux ratio related to top product rate, i.e. throughput. (c) Reboil rate related to reflux rate by level controller which ensures that liquid reaching bottom of column is not removed as bottom product is reboiled.

Distillation

continued

in Figure 5, where a level controller is used to establish the balance between reflux and reboil heat loads; in this case the process is not fully controlled without it.

Reboiler level is not generally satisfactory as part of the control system, unless special steps are taken to improve the control characteristics, as suggested by Ball and Isaac (6). The system shown in Figure 5 is not recommended, but has been included to illustrate the importance of complying with the three Rules for full control. The normal purpose in controlling reboiler liquor level is either to provide a smooth flow from it, or to avoid emptying or overfilling it.

Conditions for quality control are frequently specified in the literature without any theoretical justification. Thus, the heat supply to the reboiler is often controlled from the pressure drop across the column. This method cannot possibly locate the composition pattern and does not even relate the heat supply to the throughput of the still; it simply provides a means of operating a column at a given fraction of the flooding point, but in itself bears no relation to product quality.

Application to design

The effects of imposed variations on the dynamic balance would be

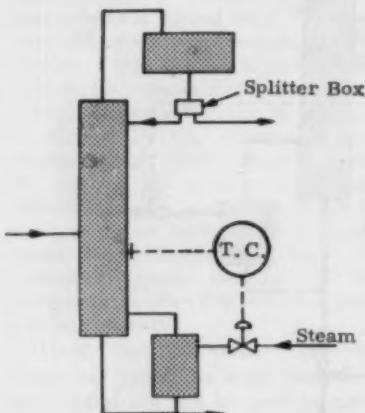


Figure 6. Composition pattern positioned by control of temp. at a point in the column. (b) Reflux rate related to top product rate. (c) Reflux rate related to reboil rate by temp. controller since a stable position of the temp. pattern depends on dynamic balance between the two.

extremely difficult to allow for if treated as a combination of transient phenomena. The problem can be simplified by considering the variations as fixed changes and estimating their effects. To illustrate a simple method of approach, the stage-by-stage design of a still to separate

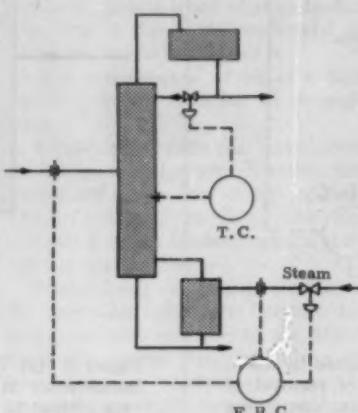


Figure 7. (a) Composition pattern positioned by control of temp. at a point in the column. (b) Reboil rate related to feed rate. (c) Reflux rate related to reboil rate by temp. controller since a stable position of the temp. pattern depends on dynamic balance between the two.

methanol and water is discussed on a numerical basis. The design is based on the method of McCabe & Thiele (7), although the arguments apply to any other method.

The feed of 6.5 mol% methanol is separated at atmospheric pressure into a top product of 99.92 mol% methanol and a bottom product of 0.013 mol% methanol. The feed is at the boiling point, and a reflux ratio of 4:1 is chosen from economic considerations. The number of theoretical plates required on this basis is 20, with 11 plates above and 8 below the feed plate, Figure 11. The design is not complete at this stage, for no allowance has yet been made to cope with variations which must be anticipated under works conditions. The only allowance which can actually be made at the design stage is either change in reflux ratio or change in the number of plates. As pointed out by Harbert (4), it is more economical to make the allowance on the number of plates. In this section an estimate is made of the number of plates which must be allowed to deal with certain specified variations.

The important variables are:

- operating pressure.
- feed rate, composition, and enthalpy.
- heat supply to the reboiler.
- heat removal at the condenser.

Changes in these variables are reflected as changes in the liquid/vapor (L/V) ratio inside the column. Their effects can be estimated by considering each one separately, assuming that the others remain constant.

Feed rate and composition. The control of feed rate should be the best that is economically warranted, since a steady feed will assist the control system to deal with other more difficult variables. The effect of variations in feed composition on the purity of top and bottom products has been examined by Bauer & Orr (5) for a hypothetical binary mixture in a column with a fixed number of plates and for different reflux ratios. Their analysis indicates that the control of composition *from a particular point in the column* provides a closer control of product quality for a given variation in feed composition. When the control of the composition of both top and bottom products was considered, a trial-and-error solution was found necessary to fit a fixed number of plates.

The method adopted in the methanol/water example is to assume a variation in feed composition, and to determine the number of plates required to produce top and bottom products of the purity specified in the static design and at the same reflux

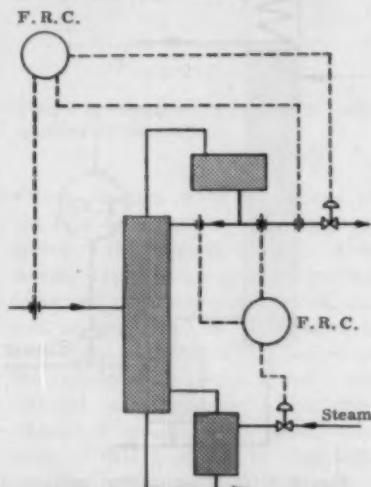


Figure 8. Composition pattern positioned by taking off as top product a controlled fraction of feed flow. (b) Reflux rate related to top product rate. (c) Reboil rate related to reflux rate by flow ratio controller adjusting reboil rate to maintain given flux ratio.

ratio. Expected variation in feed composition is considered to be ± 1.25 mol% methanol. A reduction in methanol concentration requires more plates for the same reflux ratio.

The number of plates required at a reflux ratio of 4:1 and a feed composition of 5.25 mol% to produce the same top and bottom products as in the first stage design is increased to 22, 12 above the feed and 9 below. Feed Enthalpy. Variations in feed enthalpy have two distinct effects, which are considered separately for convenience.

The first is the effect of a change in feed enthalpy on the number of theoretical plates required to produce a product of the desired purity at a given reflux ratio. This is well known and is dealt with fully in the literature.

The second effect is that on the overall materials balance, which leads to a change in the distribution of any one component of the feed between the top and bottom products. Since the operation of a distillation plant depends upon the energy balance rather than on materials balance, this is only to be expected, but the practical implications are not always realized. The particular way in which the effect is felt depends on the method of controlling the reflux in each case, that is, whether a reflux divider or flow ratio control (between top product and feed) is used. When the enthalpy of the feed changes, the effect cannot be allowed for at the

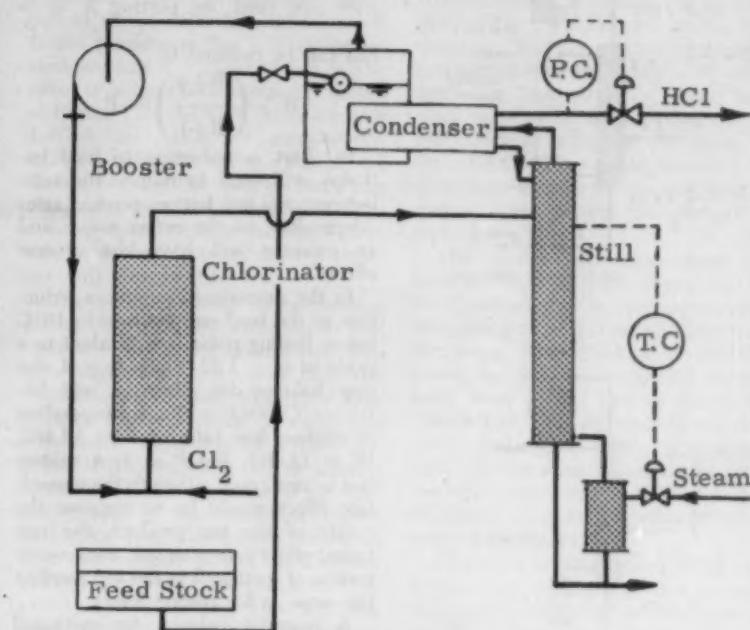


Figure 10. (a) Control system-chlorinator/stripper composition pattern located by temp. control at a point in the column. (b) Reflux rate related to feed since the material to be chlorinated is vaporized by the reflux. Chlorine supply to chlorinator is directly proportional to the material chlorinated. (c) Reflux rate related to reboil rate by dynamic balance.

condenser or by increasing the number of plates. The only method remaining is a change in heat supply at the reboiler. The general effect of changes in feed enthalpy on the overall materials balance can be seen more clearly from the following argument in which the quantities are stated in terms of latent heat units.

The following assumptions are made:

a. molal latent heat is constant round the system.

b. there is no subcooling in the condenser.

c. no heat is lost to the surroundings.

Let P = top product rate when feed is boiling (mols.)

W_b = bottom product rate when feed is boiling (mols.)

W = bottom product rate when feed is cold (mols.)

F = feed rate of boiling feed (mols.)

O = reflux rate when feed is boiling (mols.)

$q-1$ = the quantity of heat required to raise the feed to boiling point, divided by the latent heat.

Now suppose the temperature of the feed falls below boiling point such that $q-1$ is positive. This will cause $(q-1)F$ mols of additional vapor to be condensed in the stripping section to bring the feed to boiling point. The liquid flow in the stripping section is now $O+qF$ and the vapor flow

$L = \frac{O+qF}{O+P}$, resulting in an $-V$ ratio of $\frac{V}{O+P}$,

slightly greater than with boiling feed. The vapor rising in the refining section is reduced to $O+P - (q-1)F$, and when the condenser has felt the effect, the reflux will reduce to

$$\left(O - \frac{O}{O+P} \right) (q-1)F$$

and the product to

$$\left(P - \frac{P}{O+P} \right) (q-1)F,$$

assuming the reflux ratio remains unchanged.

In the absence of corrective action, the materials balance has now changed from $W_b = F - P$ with boiling feed, to

$$W = F - \left[\left(P - \frac{P}{O+P} \right) (q-1)F \right]$$

continued

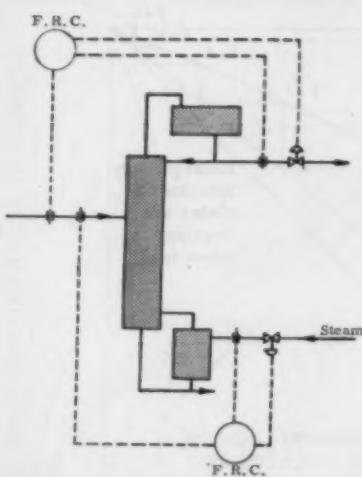
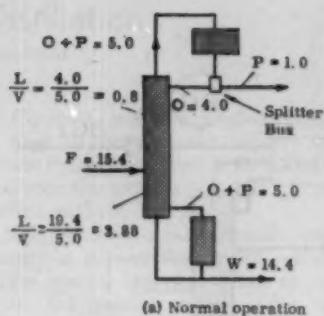
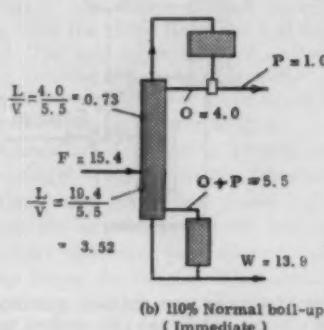


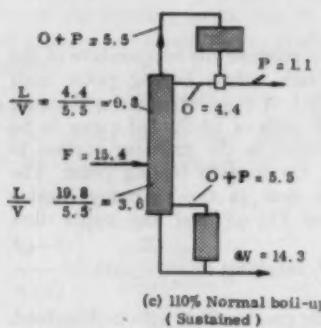
Figure 9. (a) Composition pattern positioned by taking off as top product a controlled fraction of feed flow. (b) Reboil rate related to feed rate. (c) Reflux rate related to reboil rate since condensate not removed as top product returns to column as reflux.



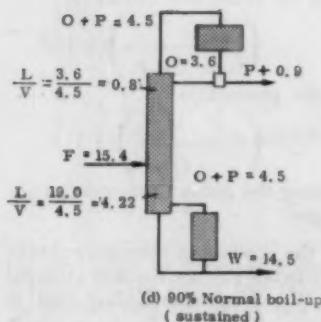
(a) Normal operation



(b) 110% Normal boil-up (Immediate)



(c) 110% Normal boil-up (Sustained)



(d) 90% Normal boil-up (sustained)

Figure 12. Methanol/water separation at 4:1 R.R. Effect of variations in boil up.

with cold feed. By putting $R = \frac{O}{P}$ this can be reduced to:

$$W = \left(\frac{R+q}{R+1} \right) F - P$$

In short, a reduction in feed enthalpy will tend to reduce the ratio between top and bottom product rates (depending on the reflux ratio) and an increase will have the reverse effect.

In the numerical example, a reduction in the feed temperature to 10°C below boiling point is equivalent to a value of $q = 1.02$. Since $R = 4$, the new balance for ($P = 1$) will be: $W = (1.004F - 1)$, corresponding to relative flow rates of $F = 15.462$, $W = 14.462$, and $P = 1$. A splitter box is used, and, although the immediate effect would be to improve the purity of the top product, the sustained effect is to maintain the concentration of methanol in the top product the same as for boiling feed.

A material balance for methanol then gives:

$$Wx_w = Fx_f - Px_p \\ 14.462 x_w = 0.065 \times 15.462 \\ - 0.9992 \times 1$$

$$\therefore x_w = \frac{1.00503 - 0.9992}{14.462} \\ = 0.000403 \text{ mol. fraction}$$

For boiling feed $x_w = 0.00013$.

This result shows that a reduction of

10°C in the feed temperature has resulted in a bottom product with a methanol concentration 325% times the value corresponding to a boiling feed. This effect has occurred to satisfy the new material balance demanded by the change in enthalpy of the feed and is quite independent of the number of plates or reflux ratio. Flow ratio control is unable to take corrective action, because a 325% change in methanol concentration corresponds to a change of only 0.4% in flow rate, beyond the sensitivity of a standard commercial instrument.

It is evident from the above argument that when high purity products are being prepared, careful control of the feed temperature is essential. A change in feed enthalpy is ultimately reflected as a change in heat required at the reboiler, and when the heat input to the reboiler is controlled from a temperature signal at the correct position in the column, there will be a relatively prompt and accurate response to the change, the normal material balance being restored. The superiority of temperature control is indicated.

Heat supply to reboiler and heat removal at condenser. The extent of the change in the L/V ratio before corrective action from the control system is effective depends upon the particular arrangement. All commercial instruments operate within tolerances which vary according to type and quality. Thus, when temperature con-

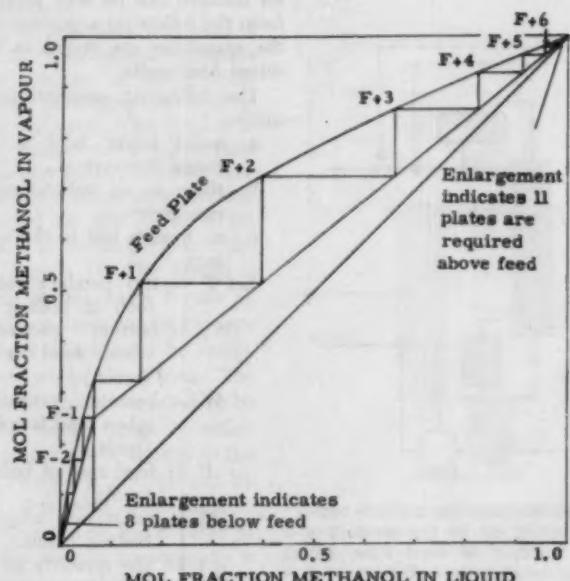


Figure 11. McCabe-Thiele diagram for methanol/water separation at 4:1 reflux ratio. Total of 20 plates.

trol is selected, the temperature measuring element, controller, and controlled element (e.g. steam valve) all contribute additive tolerances which together with the transmission lines, introduce time lags.

In most distillation applications, however, the effectiveness of the instrumentation is considerably reduced by the poor dynamic response of the process itself, and unfortunately, this is the one important factor about which least is known. Some progress has been made in this difficult field by Rosenbrock (8), Armstrong & Wilkinson (9), Rose & Williams (10) and Boettner (11), but the information available at the present time has only a very limited application. Due to the response lag of the process, a significant deviation from the design value of, say, the heat input to the reboiler can occur before the control system produces the necessary corrective action in the column. In this methanol/water example, a 10% change in boil up is assumed to illustrate the method of dealing with it. In many installations a smaller allowance may possibly be sufficient.

The immediate tendency of an increase in boil up is to reduce the L/V ratio, both above and below the feed, because of the increased vapor flow, but the effect of a sustained change depends on the arrangement of the control system at the top product off-take. In the example, a splitter box will be used. Figure 12a shows the L/V ratios during normal operation. These are 4.0/5.0 and 19.4/5.0 in the rectifying and stripping section, respectively. The immediate effect of a

10% increase in boil up is shown in Figure 12b, where the increased vapor rate at the reboiler has not been felt at the condenser; the L/V ratios are modified to 4.0/5.5 and 19.4/5.5. The effect of a sustained increase is shown in Figure 12c; the L/V ratios are now 4.4/5.5 and 19.8/5.5 respectively, which satisfies the reflux ratio of 4:1 maintained by the splitter box. The condenser must be capable of condensing vapor at this increased rate, otherwise the purity of the top product will deteriorate.

The potential change in top product purity due to a 10% variation in boil up can be indicated on the equilibrium diagram by assuming that the distillation plant has attained a new dynamic balance under the changed conditions. Referring to Figure 13, line 1 is the operating line at a reflux ratio of 4:1 and normal boil up, corresponding to the conditions shown in Figure 12a. The immediate effect of a 10% increase in boil up is shown by line 2, which corresponds to L/V ratios of 4.0/5.5 and 19.4/5.5, the feed conditions and bottom product concentration remaining unchanged. An energy balance at this instant would thus require a top product concentration of 69 mol% methanol. This cannot occur if the condenser is sufficiently large to condense the increased quantity of vapor because the effect would be to restore the L/V ratio, since the splitter box would maintain a reflux ratio of 4:1. This condition is represented by line 3, which is parallel to, but displaced from line 1, because the L/V ratio in the stripping section differs from

that at the normal boil up. Should the 10% increase be sustained, the temperature pattern would move up the column, and the top product concentration would tend to approach 91 mol% methanol. This tendency would take some time to be realized because of the buffering action of the liquid in the column. There would, however, be some deterioration before any control system could restore the process to normal conditions.

The changes discussed above are transient and cannot, therefore, be truly represented on an equilibrium diagram. Figure 13 merely illustrates the trend. The effect of a 10% decrease in boil up, estimated in the same way, Figure 12d, is shown by lines 4 and 5 on the equilibrium diagram, Figure 13. This again shows that energy balance considerations are more significant than the number of plates, in controlling the performance of the column.

Except in certain cases, as for example when a dephlegmator is used to provide the reflux, a condenser is relatively insensitive to changes in coolant supply. Because of this, changes at the reboiler are much more significant. In any case, a variation in conditions at the condenser is finally reflected as a change at the reboiler, and a simple approach towards a quantitative solution of the effect of variations can, in general, be made by considering changes in L/V ratios arising from the resulting changes at the reboiler. In the example, a McCabe-Thiele diagram is prepared in which L/V ratios of 3.6 and 4.22 are

continued

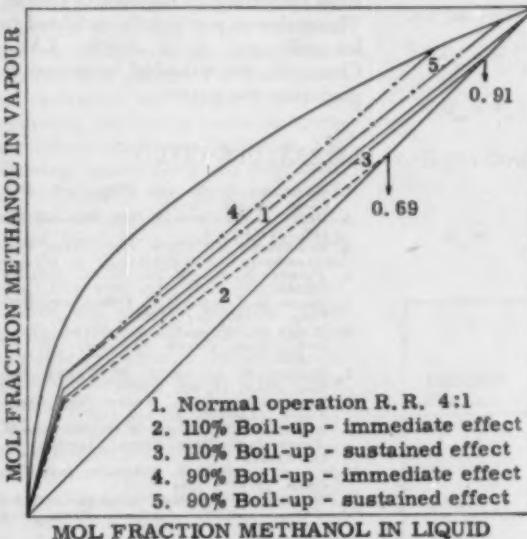


Figure 13. Potential change in top product purity due to ten percent variation in boil up.

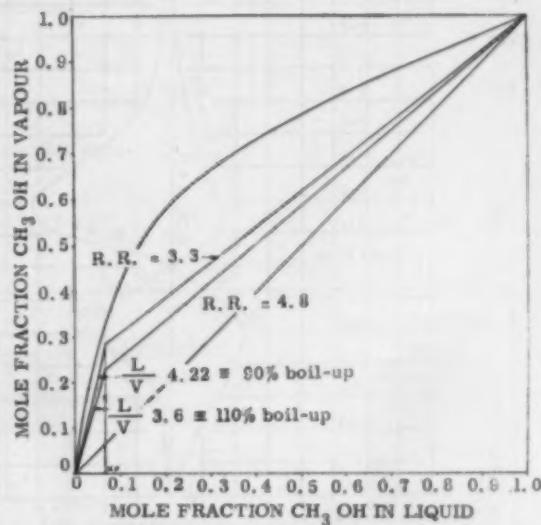


Figure 14. Operating lines for the rectifying section converted to reflux ratio.

Distillation

continued

drawn for the stripping section in accordance with Figures 12c and 12d for 10% changes in the boil up, assuming bottom product purity and feed conditions as previously stated for normal operation. Operating lines for the rectifying section are then drawn to the required top product concentration, and the L/V ratios determined and converted to reflux ratios. These are calculated to be 3.8:1 and 3.3:1 Figure 14. The lower reflux ratio requires more plates and a round figure of 3:1 is used. It is found that 24 plates are required, 13 above and 10 below the feed plate as compared with 20 determined for the static design.

To present the worst case, it is assumed that the reduction in feed composition occurs at the same time as a 10% decrease in the boil up which has an effect similar to a reduction in reflux ratio from 4:1 to 3.3:1 Figure 14. The required number of plates was, therefore, based on a feed composition of 5.25 mol% and a reflux ratio of 3.3:1 (minimum reflux ratio is 3:1 for these conditions). The calculated number was 26; 13 above and 12 below the feed plate.

In this example, therefore, the final

design is based on the number of theoretical plates required to cope with a reduction in methanol content of the feed, combined with a decrease in boil up. The number of theoretical plates provided in the column is 26, that is, six more than is calculated under static conditions ignoring energy balance considerations.

In deciding the method of control, temperature patterns, starting from the feed plate, are then drawn corresponding to reflux ratios of 3:1, 4:1 and 5:1, Figure 15. From this, a temperature deviation pattern can be plotted, showing the change in temperature with reflux ratio on each plate referred to the temperature at a reflux ratio of 4:1, Figure 15. This diagram shows that a signal of sufficient magnitude can be obtained for single point temperature control to be used, and that an impulse point could be located within five plates either side of the feed plate. A suitable control system is shown in Figure 6. The temperature impulse point for controlling steam to the reboiler would be located below the feed plate to reduce the time lag. The second plate below is actually recommended, but alternative positions are provided. This is necessary because, depending on the frequency of fluctuations and the speed of response of the process to control, (neither of which will be

known until the plant is in operation), it may be found better to accept a smaller impulse temperature range to shorten the process path between the impulse point and the reboiler. The best point is always a compromise between these two requirements.

Conclusion

The constant conditions assumed in the paper study of a distillation problem are unattainable in practice and a control system based upon energy balance considerations must be set up. Under works conditions, variations are continuously imposed on a plant due to the limitations of commercial instruments and to other external changes. In the worked example, additional plates equivalent to a 30% increase in the number calculated, assuming constant conditions, are necessary to deal with variations anticipated under works conditions. It may be considered that the method leads to an excessive allowance, particularly when a large number of plates is involved. This has not been proved in practice however, and it must be remembered that the degree of accuracy involved in estimating plate efficiencies, values of H.T.U. and H.E.T.P. is of the same order. Further work on the dynamic response of the process will however, enable a more accurate assessment to be made.

ACKNOWLEDGMENTS

Acknowledgment is due to the late E. J. Eaton, B.Sc.(Tech.) A.M.I. Chem. E., who specified the general rules for setting up the control system. The author is particularly indebted to his colleague, J. J. Settle, A.M.I. Chem. E., for valuable assistance in preparing the paper.

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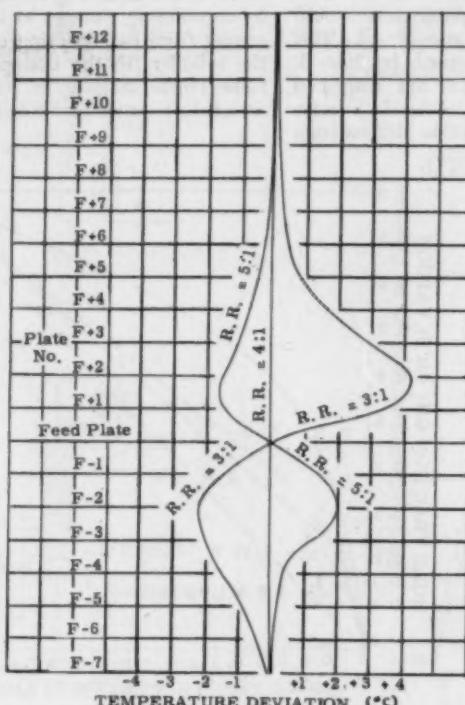


Figure 15. Temperature deviation diagram.

Optimum trim cooler temperature

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AIR-COOLED
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The development of an optimum equation for establishing the intermediate temperature for a sensible fluid leaving the air fin cooler and entering the (water) trim cooler has one significant implication: the amount of money which can be saved in a single plant facility can be surprisingly large. This is a fact which has not yet attained its logical prominence.

A typical cooling loop is shown in Fig. 1. The cooling water source is considered constant and the cost of the water is taken to reflect the cost of providing the water. In this case it is not necessary to consider separately how the water is provided. Kern (1) has indicated that the air fin cooler, operating at the air dry bulb, will not be economically desirable for producing a trim temperature which approaches the air temperature very closely. For this reason the derivation can be simplified by employing arithmetic mean temperature differences where applicable. The following assumptions are employed:

(a) Arithmetic mean temperature differences are applicable. (b) The number of tube rows and the face air velocity of the air-fin cooler are constant. The over-all coefficient of heat transfer will also be constant when the fluid velocity is constant or the tube side resistance is negligible. (c) The water velocity in the trim cooler is constant.

When water flows through the shell, the derivation will still be satisfactory over narrow ranges of exchanger sizes. In a trial-and-error solution, however, the numerical value of the ratio of water flow area to heat transfer surface must be altered to meet the specific range of sizes for which the

calculation is made. The value of the over-all heat transfer coefficient must then also vary with the size of the trim cooler.

1. Qualities of the arithmetic mean temperature difference.

Cost equation

$$C = C_a A_a + C_w A_w + \frac{7.5}{60} \frac{C_w W_w}{\rho_w} \quad (1)$$

Total heat balance

$$Q = W C_p (T_1 - T_3) \quad (2)$$

$$Q = Q_a + Q_w \quad (3)$$

Air fin cooler heat balance

$$Q_a = W C_p (T_1 - T_2) \quad (4)$$

$$Q_a = W_a C_a (T_{a2} - T_{a1}) \quad (5)$$

Air Fin Cooler heat transfer equation

$$Q_a = \frac{U_a A_a}{2} [(T_1 - T_{a2}) + (T_2 - T_{a1})] \quad (6)$$

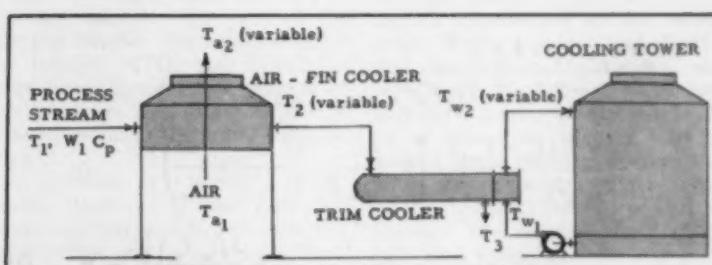


Figure 1. Trim cooler loop.

Optimum trim cooler temperature

continued

Trim cooler heat balance

$$Q_w = W C_p (T_3 - T_1) \quad (7)$$

$$Q_w = W_w C_{pw} (T_{w2} - T_{w1}) \quad (8)$$

Trim cooler heat transfer equation

$$Q_w = \frac{U_w A_w}{2} [(T_3 - T_{w2}) + (T_3 - T_{w1})] \quad (9)$$

Air continuity equation

$$W_a = \rho_a \beta_a A_a V_a \quad (10)$$

Water continuity equation

$$W_w = \rho_w \beta_w A_w V_w \quad (11)$$

2. Conditions for an optimum. Differentiate Eq. (1) with respect to the trim temperature, T_2

$$\frac{dC}{dT_2} = C_a \frac{dA_a}{dT_2} + C_w \frac{dA_w}{dT_2} + \frac{C_{ew}}{8 \rho_w} \cdot \frac{dW_w}{dT_2} = 0 \quad (12)$$

3. Evaluation of dA_a/dT_2 . Eliminate Q_a from Eqs. (4) and (5) and eliminate Q_w , W_a , and T_{a1} from Eqs. (4), (6) and (10). The resulting equation for A_a may be differentiated with respect to T_2 .

4. Evaluation of dA_w/dT_2 . Eliminate T_{w2} from Eqs. (7), (8), (9) and combine with Eq. (11). This expression for A_w may now be differentiated with respect to T_2 .

5. Evaluation of dW_w/dT_2 . Differentiating Eq. (11) and substituting for dA_w/dT_2 the value obtained by the above process, dW_w/dT_2 may be obtained.

6. Final Equation

$$\begin{aligned} & \frac{2 C_a W C_p (T_{a1} - T_1)}{(T_1 + T_2 - 2 T_{a1})^2} \left[\frac{1}{\rho_a \beta_a V_a C_{pw}} + \frac{2}{U_a} \right] \\ & + \frac{2 W C_p (T_3 - T_{w1})}{(T_2 + T_3 - 2 T_{w1})^2} \left[C_w \left(\frac{1}{\rho_w \beta_w V_w C_{pw}} + \frac{2}{U_w} \right) \right. \\ & \left. + \frac{C_{ew}}{8} \left(\frac{1}{C_{pw} \rho_w} + \frac{2 \beta_w V_w}{U_w} \right) \right] = 0 \quad (13) \end{aligned}$$

Equation (13) has been programmed for the IBM-610 and the Burroughs E-101 small computers and has been solved numerically a number of times for particular industrial systems operating with 95°F dry-bulb air, 85°F water, using local cost data and arbitrary flow area-to-surface ratios for the other variables. Where it is desired to cool the process stream to a 100°F outlet temperature, the optimum trim temperature usually is calculated to be about 140°F when using a freely available source of water such that the water cost consists only of pumping and maintenance charges. If it is necessary to include in the cost of the water the cost of paying out water facility at approximately \$32 per GPM over three years, the optimum trim temperature will be about 125°F. As the cost of the water goes up, due either to decreased payout time or increased facility costs, it becomes advantageous from Equation (13) to do a greater part of the cooling in the air-fin cooler, and thus the optimum trim temperature obviously rises.

Using Equation (13), or any other analytical criteria, the potential savings in the design of new facilities employing air-fin coolers, or combined trim coolers, have proved exceptionally large. The singular exceptions have been some rough-and-ready ocean salt water facilities, and in those it is believed that the costs allocated to erosion and maintenance were generally on the low side.

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NOMENCLATURE

A_a = Heat transfer area of air-cooled exchanger, sq. ft.
 A_w = Heat transfer area of water-cooled exchanger, sq. ft.
 C = Total annual cost of exchangers and cooling tower, including capital, operating, and maintenance costs, \$/yr.
 C_{ew} = Total annual cost per sq. ft. of air-cooled exchanger, \$/sq. ft. yr.
 C_{pw} = Total annual cost of the cooling water source including exploration, development, and piping \$/(gpm) (yr.).

continued

Nomenclature

continued

C_w = Total annual cost per sq. ft. of water cooled exchanger, \$/sq. ft. yr.

C_p = Specific heat of process stream, Btu./lb. °F.

c_{pa} = Specific heat of air, Btu./lb. °F.

= Specific heat of water, Btu./lb. °F.

Q = Total heat transferred from process stream, Btu./hr.

Q_a = Heat transferred in air-cooled exchanger, Btu./hr.

Q_w = Heat transferred in water-cooled exchanger, Btu./hr.

T_1 = Process stream inlet temperature, °F.

T_2 = Process stream trim temperature, °F.

T_3 = Process stream outlet temperature, °F.

T_{at} = Air inlet temperature, °F.

T_{ao} = Air outlet temperature, °F.

T_{w1} = Water inlet temperature, °F.

T_{w2} = Water outlet temperature, °F.

U_a = Over-all heat transfer coefficient in air cooled exchanger, Btu./hr. (sq. ft.) (°F.)

U_w = Over-all dirty heat transfer coefficient in water-cooled exchanger, Btu./hr. (sq. ft.) (°F.).

V_a = Velocity of air, ft./hr.

V_w = Velocity of water, ft./hr.

W = Weight flow rate of process stream, lb./hr.

W_a = Weight flow rate of air in air-cooled exchanger, lb./hr.

W_w = Weight flow rate of water in water-cooled exchanger, lb./hr.

β_a = Ratio of face area to heat transfer area in air-cooled exchanger.

β_w = Ratio of water flow area to heat transfer area in water-cooled exchanger.

ρ_a = Density of air, lb./cu. ft.

ρ_w = Density of water, lb./cu. ft.

Economics of air fin coolers

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While it is a general rule that economics are favorable for air cooling to within 40°F of the design dry-bulb air temperature, approach temperatures less than 40°F have been economically justified.

Air fin equipment may be more expensive than shell and tube equipment. However, when the added off-site costs for cooling water are included and compared to power distribution costs, the total investment for the air coolers is often less. Further investment savings are indicated by a combination water and air cooled system. A comparison of the total investment and operating costs of the three alternates is shown in Table 1.

A recent study for a reduced crude cooler, Table 2, illustrates the important part played by factors such as, product viscosity, allowable pressure drop, and available ground area.

The alternates, Cases II and III, not only increased the duty of the unit considerably, but greatly reduced the possible MTD, and required a much lower transfer rate because of the extremely high viscosity of the reduced crude at the lower temperatures.

In addition to complete refinery studies, projected process expansion studies are reviewed to determine the applicability and economics of air cooling, where previously it was usually planned to expand existing cool-

ing-water facilities. As an example, such a study recently completed for one refinery indicated that air cooling should be maximized for all future units. The over-all indicated advantage of using air fin coolers was a capital savings of \$2,600,000 through elimination of the cooling water system

AIR-COOLED
HEAT
EXCHANGE

expansion, and the differential investment cost of air fin over shell and tube equipment. Besides this, were recurring savings in operating and maintenance and expense charges. In the long range outlook there is also the advantage that as more air cooled units are installed, there will be less over-all dependence on the cooling water system pumping and distribution facilities, and operational variables such as maintenance, corrosion and water treatment. The first analysis of this study showed 100% air cooling to be more economical than 100% water cooling on an overall basis of planned refinery process expansion. The detailed study of the individual units, however, may prove water cooling to be more economical

continued

Air fin coolers

continued

for certain duties. As an example, a detailed estimate study was made of an overhead condenser for a pipe still cooling facility. The alternates considered were: (a) shell and tube with an expanded cooling water system, (b) an all air system, and (c) a combination of shell and tube plus a small onsite cooling tower. A comparison of the estimated costs of these alternates is summarized below.*

In the transition period between the design-economics decision to use this equipment, and its actual installation, the evaluation of competitive designs for air fin coolers presented many problems. With several competitive suppliers and an apparent variance in their rating methods and mechanical design, the procurement engineer was faced with the task of selecting equipment that would most attractively fulfill the process operating conditions, and investigating and determining a standardized approach to the selection of mechanical equipment components for minimizing spare parts requirements and maximizing interchangeability.

Present practice is to furnish the manufacturer with information relat-

ing to tube side duty, process flow conditions, design air temperature, mechanical equipment, and fabrication requirements. The manufacturer establishes the mean temperature difference and transfer rates, and supplies the surface requirements, air load data, and the usual cost and delivery information.

Because of the two general approaches to the basic design of air fin equipment (high surface-low horsepower, or low surface-high horsepower), competitive proposals have often disclosed wide differences in the size of units offered for a given duty. To limit the wide selection of equipment sizes possible through the various combinations of surface and horsepower, the manufacturers are furnished with two additional facts of information: power investment and operating costs, and available ground area.

Field operating experience with air fin coolers has influenced design concepts and future design and performance requirements for this equipment. Some of the more important considerations are:

1. Maintenance costs

Maintenance costs for air fin coolers are presently estimated at one-half those for shell and tube equipment. Such maintenance includes replace-

ment of fan bearings, V-belts, external and internal cleaning of finned tubes, and a scheduled, routine inspection and maintenance of driver equipment.

2. Operating costs

Estimate studies of total operating costs made for future expansions of process units, have shown possible savings to be as much as 35% over shell and tube exchangers.

3. Space requirements and location within process areas

Area requirements of air fin coolers are estimated to be about 15-20% greater than for shell and tube exchangers. Air fin coolers are presently being located within battery limits. They present, however, some concern from a safety standpoint due to their vulnerability to damage in the event of fire exposure and because tube leakage would be to the atmosphere rather than to a closed system. They are not located over pumps, compressors, electrical switchgear, control houses, and in general, the amount of equipment such as drums and shell and tube exchangers located beneath them are minimized. Wherever possible, equipment operating about 600°F is not located beneath air fin coolers.

4. Air side fouling

Experience thus far has indicated that air side fouling is essentially negligible. The surfaces can be kept clean by various methods such as hot water spray, steam cleaning, and hand brushing. It has been observed that only the air inlet faces are subject to fouling, with middle and top side rows being essentially free of dirt.

5. Fluid exit temperature and design air temperature

The design dry-bulb air temperature limits the temperature to which the process fluid can be air cooled. While economics are generally favorable for air cooling to within 40°F of the design air temperature, in some cases, total air cooling investment costs do not exceed total water cooling investment costs until the process fluid exit temperature is within 20°F of design air temperature. It is common practice to select a design air temperature as the dry-bulb temperature which is not exceeded 95% of the time. However, it is believed practical to add 5°F to this for the possible ambient rise due to recirculation of hot effluent air.

For effective year-around performance, it is also important that winter-time temperatures be considered. Fan horsepower requirements must be developed for both design temperature and lowest winter temperature anticipated.

	Alternate (a)	Alternate (b)	Alternate (c)
*Total investment	\$430,000	\$910,000	\$895,000
Operating costs	80,000	175,000	75,000

Table 1. Investment and operating cost comparison of water cooled, air cooled, and combination water and air cooled system.

FUEL OIL COOLER
Duty—74.7 MM Btu./Hr.
Oil temp., in & out—260°F & 150°F
Design air temp.—95°F

Equipment	Investment Costs		Annual Operating		Percent Saving	
	Total	Costs	Costs	Investment	Operation	Base
(a) Water cooled	\$729,000	\$55,000				
(b) Air cooled	\$694,000	\$54,000		5%	2%	
(c) Air cooled + Trim Cooler (shell & tube)	\$549,000	\$31,000		25%	43%	

Table 2. Reduced crude cooler.

Estimated increased finned surface, percent	Increase cost percent	Estimated increased plot area, percent	
		Case I	Case II
Case I 100% (146,000 sq. ft.)	100%	100% (30 ft. × 25 ft.)	
Case II 170%	170%	160%	
Case III 270%	270%	205%	

What's the A.I.Ch.E. doing for you?

By I. Leibson, E. M. Jones, John J. McKetta*

Here are the detailed views of the members of the South Texas Section on just what they think

A.I.Ch.E. is doing and/or not doing for them. You may agree or disagree with the views of your fellow members in Texas, but either way there is considerable food for thought here.

The purpose of this survey of the entire South Texas Section was to determine (a) attitudes on certain professional problems, (b) the rating of A.I.Ch.E. performance in a number of important activities, and (c) suggestions for additional activities which A.I.Ch.E. might undertake either at a local or a national level.

The response to the survey was gratifying. Out of 685 lengthy questionnaires mailed to the members, over 500 (i.e., 73 percent) were completed and returned. In addition, many of the respondents wrote lengthy comments.

The comments received were, in general, sincere and constructive. Some of the comments brought out areas which require further study on the local and national levels of the

A.I.Ch.E. (No attempt was made to ask the same type of questions as those asked by the L. B. Smith Committee which did excellent work for the entire Institute in 1953 (1).)

The percent in each category of those responding to the questionnaire is shown in Table 1. The questionnaire was entirely anonymous except for the general questions necessary to obtain the data for Table 1.

The over-all results of the questionnaire are shown in Table 2, which is broken down into three divisions. Table 2-A is concerned with the question, "Your opinion concerning certain problems." Table 2-B is based on the question, "How would you rate A.I.Ch.E. performance in each of the following activities?" Table 2-C is concerned with the problem, "What

continued

TABLE 1
Description of respondents

NATIONAL A.I.CHE. MEMBERSHIP STATUS	PERCENT	YEARS OF PROFESSIONAL EXPERIENCE	PERCENT
Member	40.6	Zero-5	16.8
Associate Member	57.4	6-10	27.0
Affiliate Member	1.2	11-15	20.6
Nonmember	0.8	16-20	20.0
		21 Plus	15.8
PRESENT PROFESSIONAL ACTIVITY			
Research and Development	24.7		
Process Design	14.8		
Sales or Sales Technical Service	6.9		
Plant Operations	16.9	ARE YOU: Self-Employed	8.9
		Employed	96.1
Plant Technical Service	19.8	ARE YOU: Supervisory	51.4
Teaching	2.7	Foreman	6.7
Corporate Management	9.0		
Other	5.2	Nonsupervisory	41.9

Note: 104 total companies were represented by the above respondents.
15 of these companies have more than 10 members each.

* I. LEIBSON, Humble Oil & Refining Co., Baytown, Texas, Vice-Chairman, Southern Division of the National A.I.Ch.E. Membership Committee.
E. M. JONES, Monsanto Chemical Co., Texas City, Texas, Chairman, National A.I.Ch.E. Membership Committee.
JOHN J. MCKETTA, University of Texas, Austin, Texas, Director of National A.I.Ch.E.

TABLE 2-A

Your opinion concerning important problems

% YES	% NO	% DON'T KNOW	TOTAL NUMBER OF ANSWERS	WHOSE RESPONSIBILITY? NATIONAL, LOCAL, INDIVIDUAL
1. Do you favor the unification of the entire engineering profession by the formation of an American Engineering Association of which A.I.Ch.E. would be one branch?	44.6	41.7	13.7	489
				N
2. Do you favor state registration of engineers?	62.0	26.4	11.6	489
				I
3. Are you in favor of collective bargaining for engineers by professional unions?	6.2	89.3	4.5	484
				I
4. Do you feel that collective bargaining is compatible with professional status?	9.6	86.5	3.9	489
				I
5. Physicians use the abbreviation M.D. after their names in all signatures, bylines, etc. Do you favor the use of Ch.E., M.S., or Ph.D. after your name in similar cases?	29.4	60.8	9.8	490
				N,I
6. Do you feel that your company gives greater recognition to A.I.Ch.E. members than to nonmember chemical engineers?	21.0	69.8	9.2	486
				N,L
7. Does your company assign engineers to subprofessional work?	44.6	46.5	8.9	484
				N,L
8. Do you have a feeling of job security in your present employment?	83.7	12.3	4.0	489
				I
9. A recurring complaint of nonmember chemical engineers asked to join A.I.Ch.E. is: "National A.I.Ch.E. is dominated by members of top corporate management." How do you feel about this statement?	35.7	43.1	21.2	501
				N,I
10. In reference to your answer to (9), do you feel that this is detrimental to the Institute?	26.2	53.4	20.4	481
				—
11. Another recurring complaint of nonmember chemical engineers asked to join A.I.Ch.E. is: "National A.I.Ch.E. is dominated by chemical engineering professors." How do you feel about this statement?	22.9	58.4	18.7	480
				N,I
12. In reference to your answer to (11), do you feel that this is detrimental to the Institute?	13.7	63.4	22.9	475
				—
13. Do you believe that the viewpoint of the nonsupervisory chemical engineer is properly considered in formulating National A.I.Ch.E. policy?	18.5	36.0	45.5	481
				N,L,I

A.I.Ch.E. Survey

continued

should A.I.Ch.E. do with the following problems?

In Table 2-A, B & C, one of the columns indicates whether a particular problem is best solved on the national level (N), local level (L), on the individual member basis (I), or combinations of these three.

All of the answers have been correlated on the basis of the individual's national membership status, his present professional activity, years of professional experience, whether or not he is self-employed or employed by others, whether he is supervisory, foreman, or non-supervisory. The entire correlations are too voluminous to be included here. Local section chairmen may obtain detailed copies of the questionnaire results from Leibson.

Comments on Table 2-A

It is interesting that the respondents favor the registration of chemical engineers even though the Smith report indicated that only 30 percent of the chemical engineers in the United States were registered. There is no doubt, from question number 3, that the South Texas members definitely are not in favor of collective bargaining for engineers by professional unions. However, there is a strong indication from the comments that the answer would not be so highly negative if the question were rephrased. Most of the respondents dislike the word "union," but feel that collective bargaining is becoming more and more necessary. It is recommended that those who plan to make a similar survey use question number 3 without the phrase, "By professional unions." Although question 4 does not contain the phrase "professional union," the connotation is still there since the respondent has just finished answering question 3.

In question number 13 the comments indicate generally that the younger members feel that the A.I.Ch.E. Council does not represent them adequately.

Comments on Table 2-B

Question number 6 is especially interesting. Although a majority of the respondents are satisfied with one of the magazines, most of those who commented indicated a dislike for the other one. Apparently this is good. Neither the *A.I.Ch.E. Journal* nor *Chemical Engineering Progress* is pub-

TABLE 2-C

What should A.I.Ch.E. do with these problems?

% YES	% NO	% DON'T KNOW	TOTAL NUMBER OF ANSWERS	WHOSE RESPONSIBILITY? NATIONAL, LOCAL, INDIVIDUAL
1. Should A.I.Ch.E. conduct periodic salary surveys to enable members to ascertain their relative economic status?	86.2	13.0	0.8	485
				N
2. Should A.I.Ch.E. operate an employment clearing house at national meetings to aid in the placement of chemical engineers in industry?	78.6	21.0	0.4	474
				N
3. Should A.I.Ch.E. survey corporate practices and management policies concerning the professional treatment of chemical engineers?	90.5	9.5	0.0	485
				N
4. A.I.Ch.E. has less than 25% of the eligible chemical engineers in the United States as members. Should A.I.Ch.E. strive to increase this percentage to as high as 90%?	80.5	18.9	0.6	481
				N,L

lished for all of the members. It is realized that there are extreme specialized interests among the members. Still, the combined answers to question 6 indicate that approximately 80 percent are satisfied.

The national and local levels have a big job to do enlightening the public, enhancing the ability of the engineers so that they will command appropriate professional and public recognition, promoting effective utilization of chemical engineers, and encouraging employers to recognize chemical engineers as professional employees.

Table 2-C leaves no doubt that the members want a periodic survey, an employment clearing house at all of the national meetings (as well as a continuously functioning employment clearing house), a survey of the corporate practices concerning professional treatment of chemical engineers, and an attempt to increase the percentage of eligible chemical engineers as members of this society.

Whose responsibility?

Since we, as individuals, make up the membership of the A.I.Ch.E., we have an individual responsibility to try to remedy as many of these problems as possible. Each local section is in a position to do the most with the problems we have, toward the progress we desire. It is only through the local section, and through us, that the national office can solve the problems. In the final analysis, each of us gets out of a society about what he puts into it. Therefore, we should help and encourage our local officers, and should take an active part on local section committees, so that A.I.Ch.E. can do the maximum for each of us.

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The writers and the South Texas Section of the A.I.Ch.E. are indebted to the following men from the Humble Oil and Refining Company. They spent many, many man-hours in tabulating and interpreting the data.

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TABLE 2-B

How would you rate A.I.Ch.E.'s performance in each of the following activities?

% EXCEL- LENT	% SATIS- FACTORY	% UNSATIS- FACTORY	% DON'T KNOW	NO. OF ANSWERS	WHOSE RESPONSIBILITY? NATIONAL, LOCAL, INDIVL.
6.1	54.8	16.8	22.3	489	N,L
4.9	46.3	23.8	25.0	486	L
1.8	18.0	51.5	28.7	490	L
33.6	55.8	8.5	2.1	471	N,L
17.6	58.0	5.9	18.5	490	N
33.0	47.9	17.3	1.8	487	N
4.1	28.2	17.6	50.1	489	N,L
1.3	20.0	67.2	11.5	470	N,L
2.5	32.4	49.2	15.9	485	N,L,I
13.5	55.9	18.0	12.6	483	N,L,I
15.2	68.2	8.4	8.2	486	N,L
5.3	46.4	32.1	16.2	487	L,I
1.5	23.2	45.3	30.6	478	N
3.5	29.4	38.5	28.6	483	N
11.9	40.2	10.3	37.6	484	N
3.7	20.4	3.7	72.2	490	N
16. Handling manuscripts of technical papers submitted for publication in <i>Chemical Engineering Progress</i> or the <i>A.I.Ch.E. Journal</i> promptly and efficiently.					

the operators report on SAFETY in air and ammonia plants

Second section of CEP's exclusive report of the actual transcript of the recent informal round-table discussion at Salt Lake City. Readers are reminded that another session on this vital subject will be held at St. Paul in September.

CHAIRMAN WALTON: The next item on the agenda is combustible gas detectors. In our own case, we use the MSA W-11 model, calibrated for hydrogen, and it has been very satisfactory. It has been used a great deal in monitoring for leaks in the cold box, checking vessels before entering, and any suspected contamination of the atmosphere in a particular vicinity. Does anyone have any preference for, or experience with, another type of analyzer?

MASON, Dow: We have had some Johnson-Williams combustible gas detectors, both at Midland and at the Sarnia plant. They have been very satisfactory for detecting small amounts of hydrogen in the atmosphere. We also have units which operate on the intake air to the air separation plant. We are in a location where a serious type of accident in any of the hydrocarbon plants could dump a

very large quantity of hydrocarbons into the air with no warning. The Johnson-Williams Analyzer is set to sound a warning signal when the concentration of combustible gas reaches 20% of the lower combustible limit on the basis of ethane. At 40% of the lower explosive limit it will shut down the whole air separation plant.

CHAIRMAN WALTON: Automatically?

MASON, Dow: Yes, this automatically trips the circuit breaker on the compressor of the air separation plant shutting it down immediately. This protects the air separation plant against the possibility of getting a combustible or explosive mixture into the compressor. We feel that this is very important and we test this detector daily. It has a switch which blocks out the relay that ordinarily shuts down the compressor. With this relay blocked, we introduce a sample of known concentration of ethane in air into the analyzer. This tests all of the equipment except the compressor shutdown relay itself. We must assume that this relay is dependable.

We are also in close proximity to a plant which could vent an appreciable quantity of butadiene into the atmosphere. Since butadiene can easily form explosive peroxides, we also have a butadiene detector on the intake air to the compressor. This detector consists of a glass tube containing some silica gel which has been treated with concentrated sulfuric acid. This gel will turn black with very small concentrations of diolefins (with four or more carbon atoms per molecule). It will show a very definite blackening within an hour with 1 p.p.m. butadiene. It is cumulative to a very high degree. This is watched closely by the operators but so far we have never had to shut the plant down because of evidence of butadiene. In fact, we usually change the tube after about a month's operation, even though it has turned black only equivalent to the amount of butadiene of 1 ppm. for one hour. This has been very satisfactory, cheap and reliable, and we think it is very worthwhile.

CHAIRMAN WALTON: Another question that was raised was the question of thermocouples in cold boxes, and I brought along examples of a thermocouple type installation which we have found most satisfactory. That is the use of a block, tack-welded to the line. We did try banded couples; couples held on with a band. They were not satisfactory because in the cooldown the rate of the shrinkage of the pipe and band were different, and in some cases you lost contact between the couple and the line and got poor readings. The welded block, slotted, with a thermocouple stuck into it and peened, seems to be quite satis-

factory and we've had no maintenance problems with it. Does anyone else have anything they want to comment about on that?

ANONYMOUS: I might mention something that we think happened where we used a thermo-well like connection on the top of the pipe in the cold box and the thing got so cold that we think we refluxed some of the purged nitrogen in the cup. If it had been upside down it would have drained, but as it was right side up we think it filled up with liquid nitrogen and caused us a great deal of difficulty.

CHAIRMAN WALTON: I would like to give a progress report on gas chromatography. At the meeting in Baltimore, Mr. Chubb gave a short talk on the gas chromatograph. That has been in service with us now for about six months and has been quite satisfactory. This was developed mainly as an A.P.I. project in conjunction with the Los Angeles Air pollution problems, and Shell also did some work on it as a part of the project in the Franklin Institute. Experience in operation with it has been very good. We've had a few maintenance problems. One of them has been with some three-way plug valves in the system. Of course they have to be lubricated and after a period of time that lubricant worked its way into the system and gave some rather erratic readings. By changing those valves to Teflon plugs, which don't need lubricant, that has been eliminated.

You can get an analysis of a sample in 1 to 1½ of an hour; the peaks are easy to read.

CHAIRMAN WALTON: We use it for intermittent samples from the reboiler vaporizer and in other ways. We're using it to study plant air pollution. In the air pollution study, we evacuate a four-liter flask, and open the stopcock at the place where we want a sample of air. With the chromatograph; in an hour and three-quarters you'll find in parts per million, or fractional parts, just what is in the air at that point. It's a useful tool.

ANONYMOUS: What elements do you determine on the chromatograph in what ranges? How long can you go?

CHAIRMAN WALTON: To illustrate: in a sample from the reboiler of the air plant, the normal butane was 0.22 p.p.m., the iso-butane was 0.65, propane at 21, and ethane at 20.

SWOPE, Southern Oxygen: In a complete analysis, do you use one or more than one sweep gas? What is the sweep gas?

CHAIRMAN WALTON: A single sweep gas, helium, for the entire analysis.

SCHMIDT, G-E: Has this principle been used with the oxides of nitrogen?

CHAIRMAN WALTON: We are now

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working on a column for determination of oxides of nitrogen. We feel we can do it without much difficulty.

ANONYMOUS: Is this analyzer used routinely or just on special occasions?

CHAIRMAN WALTON: Routinely. Eight hours every day, with at least one sample from a reboiler. One technician is kept busy.

SIMMS, Phillips Chemical Co., Bartlesville Okla.: Has anyone had chromatography trouble with xenon? We had occasion to hold a plant down for two or three days with a xenon peak that ran within 25 to 50 p.p.m., thinking it was iso-pentane.

Materials of construction

CHAIRMAN WALTON: We haven't.

The next item is Construction Materials in Practice. There's been some question as to whether special construction of relief valves is necessary. In our plant we have relief valves of 304 and 316 stainless steel, and also bronze. These have both been satisfactory. Of course, they're not normally cold, but if they operate, they get cold in a hurry. Has anyone had problems or experiences with valves?

Another question has to do with satisfactory gasket materials for cold surfaces. For a confined gasket recess we use sheet Teflon; where not confined, Teflon-filled Flexitallic gaskets. Wire-reinforced Teflon and asbestos have been used satisfactorily. We also have used sheet packing "Bel-

build up to about 40 lb. pressure, even though there was nothing between it and the vent to stop it. On startup, if liquid is in the exchangers, we found by watching the gauge carefully, we have had no more trouble with the carbon steel line, running it down to -200°F. There appears to be disagreement about standards concerning pressures at low temperatures. Is there a formula: so many pounds pressure per so many degrees below zero?

CHAIRMAN WALTON: That's a good question.

GRUNBERG, L'Air Liquide: About twelve years ago, when many large low temperature units were designed on this continent, European experience was often followed. At that time plain steel was being used down to -350°F without any trouble. Today, no one would take the risk, even in Europe, of building new plants with plain steel. The availability of stainless steel and other nickel alloys at a reasonable cost has helped in this respect. The first step was to use stainless vessels and piping operating normally at low temperatures. Stainless steel vessels and piping have been designed under the ASME Code which had to be applied everywhere in the plant. Such construction permits good welds and eliminates flange and gasket problems. With these new designs, units start in a few days without leaks. Previous units required weeks.

SZE, Hydrocarbon Research, Inc., New York, N. Y.: We use welded stainless steel and aluminum equipment and lines in cold boxes. What Walton has said about the Atlantic plant is a description of what we do.

FUNK, German Linde: Carbon steel should not be used below -40°F. To prevent liquefied gas entering carbon steel drain lines, install a separator and use the carbon lines for the gas. If you go down to -290°F, we would suggest using either copper, stainless steel, or aluminum.

GRUNBERG: L'Air Liquide: Stainless steel is a relatively expensive material. Some designers use 9% nickel steel, at low temperatures. The trouble up to now with 9% nickel steel, has been a recommended heat treatment after welding, something not usually possible after equipment manufacture. The present studies are to establish the lowest temperature at which this alloy could be used without annealing operations. It is hoped that in the future this less expensive material will find broader uses in low temperature engineering.

CHAIRMAN WALTON: Another item for discussion is oxygen piping systems: materials, design features, cleanliness, and standards of maximum linear velocity.

SWOPE, Southern Oxygen: In the smaller oxygen plants most of our problems are in filling cylinders, rather than in making nitrogen and other chemicals. We used a Kinney pump for evacuating both oxygen and nitrogen cylinders. The pump was lubricated with tri-cresyl phosphate. It worked fine on oxygen. We were evacuating cylinders for about two months. Then we put the nitrogen operation on stream, and evacuated a group of cylinders without event. As soon as we switched back to oxygen we had a violent explosion. The explosion did not occur in the pipeline or in the pump, but in the open air. This we could not explain at the time, but felt it had been caused by a static discharge, because the pump discharge happened to be near another pipeline. We grounded and bonded the two together, thinking that would eliminate the explosion cause. About a month later the same thing occurred when we again had been evacuating nitrogen cylinders and switched back to oxygen. Apparently we can evacuate oxygen cylinders continuously and have no trouble with tri-cresyl phosphate. Neither does it explode in continuous nitrogen usage, but apparently switching one to the other creates a hazard.

Both gases are pumped from the liquid phase by pumps packed with graphite rings. In spite of excellent filters in the high pressure lines, some of this graphite powder tends to go through the lines and may possibly be acting as a catalyst. For instance, we know you can't switch a liquid pump from liquid nitrogen to liquid oxygen without running into potential trouble. We also know that graphite becomes activated when pumping an inert gas such as argon. Graphite dust trapped in the filter of an argon pump will flame when exposed to air. Similar reactions have been noted when cleaning the filters of liquid nitrogen pumps. The point is, the same graphite packing could have been originally used in a liquid oxygen pump without displaying this pyrophoric characteristic.

MASON, Dow: We had trouble with packing in a liquid argon pump. The pump was leaking enough argon to form a plume of liquid argon fog. Sparkling at the edge of the plume resembled Fourth of July sparklers. We noted the similarity of this to difficulty with carbon brushes in electrical generators on airplanes operating at high altitudes. Molybdenum disulfide was suggested as a lubricant instead of graphite since graphite is actually abrasive in the absence of oil vapor or water vapor. Molybdenum disulfide powder was used in some packing that had previously contained graphite, and it worked better than any previously used. It is now standard prac-



SIMMS

WALTON

SZE

mont" gasket material for some flat-faced valves. There seems to be a number of satisfactory materials.

Another question concerns materials used for cold lines, such as a line leaving a cold box which may become quite cold in case of a plant upset. We had one case where a carbon steel blow-down line had some subzero liquid dropped into it during a shutdown and some very extensive cracks developed. Our conclusion is that any line which may receive subzero material should be made of brass, stainless steel, or aluminum. Does anyone have this problem?

LAWRENCE, U.S.I.: We had an experience last year with our oxygen line leaving the air plant. We have oxygen exchangers. When we began to start up after a shutdown, the line blew to pieces. The line thermocouple was down around -180°F. We now have a pressure gauge on the line. We found oxygen would

continued

tice to use MoS_2 as a lubricant instead of graphite in our argon, oxygen, and nitrogen pumps.

SWOPE, Southern Oxygen: I wasn't inferring that tri-cresyl phosphate is necessarily a lubricant for oxygen. I'd be the last to recommend it for that purpose, we used it for evacuation only. For oxygen compression you must use other things. We use soap water for gas compressors. Some people are using dry compressors (I believe) with graphite rings. But going back to argon for a moment, we are currently packing our pumps with a mixture high in Teflon, with good results.

HIMMELBERGER, Air Products: On our high pressure reciprocating liquid pumps we're using a Molton packing (an MoS_2 and Teflon mixture) that has proven satisfactory, providing longer packing life, and curbing the graphite problem. Long ago, when graphite and asbestos packing was commonly used, we operated a small model oxygen generator in which the pump could be used for both oxygen and nitrogen. On some occasions, immediately after the pump was converted from nitrogen to oxygen service, explosions sufficient to damage the pump occurred. Repacking the pump during conversion to oxygen from nitrogen eliminated the problem. Recently, we were consulted on an incident where graphite from a nitrogen pump packing glowed when exposed to air. It is common to see tiny sparks in the blow-by of asbestos and graphite packed argon and nitrogen pumps. Analysis of graphite from one of these pumps in service for a long time, has shown surface areas 2 to 3 times that of fresh graphite used in graphite packing. This finely divided high-surface-area graphite is, of course, very active.

With conversion of compressors from hydrocarbon to synthetic oils in mind, we requested one of our suppliers to obtain information on the effect of carbon, or other forms of dirt, on the flash point of synthetic lubricants (including tri-cresyl phosphate). Their tests showed the flash point would be reduced when the oil became dirty.

CHAIRMAN WALTON: It sounds like graphite is to be avoided.

PUTMAN, Superior Air Products: Cases have been reported where water and soap-lubricated oxygen compressors have had serious fires in the valves when switched from oxygen to nitrogen and then back to oxygen. It may be due to the partial decomposition of the soap, or overuse of soap under these conditions, so that when oxygen contacts it a fire is likely. Within the past year we have made a few close-tolerance pumps with no packing for oxygen and nitrogen use. After taking the oxygen pumps out of service to check the tolerances, we found some carbon-like residues. This was not found after pumping with nitrogen, an indication, perhaps, that partial decomposition of whatever hydrocarbons were in the oxygen, had taken place.

MARTIN, Spencer Chemical Co., Kansas City, Mo.: Speaking of air compressors for a moment, last year we switched from mineral lubricating oil to a tri-cresyl phosphate lubricant — Pydraul — because we had several fires and explosions in the air compressor discharge system. After switching to Pydraul, we had no more fires or explosions. This lubricant will burn, but we're convinced it's better in this service than hydrocarbon oil.

Shutdowns

CHAIRMAN WALTON: The next topic is shutdowns.

CULP, Grace Chemical Co., Memphis, Tenn.: It appears that we are in the unique position of having a clean gas feed to our air plant. We normally feed less than 10 p.p.m. hydrocarbons in the air stream; have never found any acetylene nor more than 5 p.p.m. methane. Therefore, we have never considered the problem of how long we can hold liquid oxygen, or liquids, in the air plant. We have held ours during every power failure—the maximum time being 10% hr. We did not analyze the liquids at the time . . . I wish we had. However, with one exception, we have never found any



MARTIN SHANER PERLEY

great hydrocarbons concentration in the air plant. The exception was 5000 p.p.m. methane. The methane was picked up through a test tank, or an unloader tank, of a multigas compressor. There was no baffle in the design, the compressor was down, and the unloaders were open between the air side and the methane side of the tank. Methane was picked up from the test tank to a running compressor. There are now baffles in that tank, and the air suction has been relocated to get it completely away from the methane reducing station.

For several years, we disposed of our liquid oxygen during shutdowns in a very slow, nerve-wracking manner. We poured it into a copper defrost header and evaporated it with a steam hose. To get all the liquid out took from 20 to 24 hrs. Generally, the operator got impatient towards the end and poured the remainder on the ground. That was just a little too nerve-wracking, so we tried to develop a better system. We tied in a two-inch line from the air heater to the bottom of the defrost stack and up into an elbow. We have a throttling valve in the air line, and a pressure gauge downstream of the throttling valve. The first ten feet of this stack are stainless steel; the rest of the 53-ft. elevation is carbon steel. At the bottom of the carbon steel section, a thermobulb was installed with an extension gauge down to the ground operating level. We maintain a minimum temperature at that point of

-20°F. This minimum was selected for carbon steel handling of liquid on the basis of a metals testing laboratory study on various steels at low temperatures. Carbon steel impact resistance is still good at -20°F, whereas it drops off sharply at about -50°F.

We were fortunate in having about 2% excess air compression capacity at our plant. The 2% excess is used to dispose of small amounts of liquid oxygen from the hydrocarbon adsorbers and from the derime of oxygen pumps. During total shutdowns we use up to one full compressor, or 1% of our compression capacity, on this disposal unit. We bring the air in through the heater at about 200°F and drop it across the throttling valve in the orifice. It drops roughly 400 lb. here, and drops approximately 180°F going into the stack, picking up the liquid oxygen being throttled into the defroster header and throwing it out the stack. The unit has worked well on intermittent service, and on total shutdowns. We never had a stack concentration above 40%, maintaining -20°F. The unit handles six tons of oxygen per hour using air at 30,000 cu. ft./hr. The gooseneck at the top was considered our biggest problem as it would throw this 40% oxygen gas to the ground level. We have run many tests on the ground level and never found it to be in excess of 25%.

During our few shutdowns we had extensive repairs in our air plant. It is packed with rock wool which (theoretically) fills all the voids in the cold box. By use of hot air purges in the rock wool, we tried to get a reasonable gas concentration for a person to enter the area to remove the rock wool. In a 10-cu. ft. section, we purged as much as 20 hr. and got analyses ranging from 10% to 75% oxygen with a sample probe. We feel it is unsuccessful to use probes in purging rock wool. Channeling is almost imminent. Therefore, we use a high volume blower of the Coppus variety—one or more, depending on the area—to keep the atmosphere at a reasonable level directly at the point of working. We consider 18-25% to be the safe limits of this atmosphere for a human being to work in; 17% appears to be the minimum safe working level. If we get into 18% we run several analyses, and get a little nervous. For extremely short intervals, we have worked in slightly over 25%, but back out if it lasts as long as 15 minutes.

We are not completely satisfied with using dilution of oxygen-rich gases, but it's the best to date. We would like something better. In the air plant derime, we use the system outlined in liquid disposal. We let it continue until we have diluted the atmosphere in the air plant itself. For other intermittent services where dilution cannot successfully be used, we try to vent on a stainless steel stack at an elevation of twenty feet, or better, through a vertical riser discharging at the top. This brings out the problem: how to keep the stack clean. We stole an idea from the tractor, put a balanced vent cap on top, and found it

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successful in keeping dirt, flying debris, etc., out of the stack and reducing the resultant explosions. The continuous purging, or the purging associated with operation of the air plant, is, by design in our plant, bleeded with the impure nitrogen before it is discharged to the atmosphere. The oxygen vented, except during startups of the air plant, seldom exceeds 1-2% of plant capacity.

Our people have not standardized on metal inspections. We would like to inspect the insides of our towers, but to do so we must cut holes in them. We are not happy with this prospect, and would like to hear what solutions are available.

SHANER, Linde Co., Tonawanda, N. Y.: Safe holding-time, in some of our plants, is about one week. This depends on the liquid condition at the time the plant is shut down. It also depends upon whether there is enough liquid to hold, and on the initial amount of contaminants in the liquid. We maintain clean liquid in the main condenser at all times, even when the plant is shut down.

CHAIRMAN WALTON: At Baltimore, people suggested as little as 15 minutes and up to 36 hours. Now Mr. Shaner mentions a week, so there's a great deal of difference here, but of course, it depends on how clean your liquid is.

SWOPE, Southern Oxygen: I can verify Mr. Shaner's statement. It's not unusual in the oxygen industry to hold liquid in columns for some period of time. As he pointed out, you generally have a very clean liquid to begin with. But it might not be recognized (and could be a source of trouble) that the liquid quality changes as it is held. When you first shut down, a quantity of reflux nitrogen from above will drop down and dilute the oxygen. But as the liquid is held over a period of time the nitrogen will gradually boil away, leaving fairly pure oxygen in the condenser or holding point. If oil-lubricated equipment is connected to the piping of the waste nitrogen line a potential hazard will develop during long periods of shutdown. Gases passing through the nitrogen line will become rich in oxygen, and may cause an explosion or fire in the oil-lubricated equipment. We had such an incident following a long shutdown.

LAWRENCE, U.S.I.: You fellows scare me when you talk about purging this liquid. We've kept it for as long as five weeks at one time. All the nitrogen drops into the liquid in the tower bottom, and as long as the liquid level is higher when down than it was before, and if you know the test when you went down, and run a test when you are down, and it still shows good or even better (it normally shows better when you shut down) I fail to see the danger. I mean, you have a better situation after a shutdown—to let it sit.

CHAIRMAN WALTON: We surely have a divergence of opinion. Of course, the longer it sits, the more it's going to evaporate; the more things are going to concentrate in it. It depends on what you start with.

SHANER, Linde: I think that depends on the design of the plant itself. The point is to provide for maintaining a clean liquid, whether the plant is in operation or not. Clean all streams of hazardous contaminants by adsorption before entering the columns.

SANDERS, Texas Co.: In holding the liquid in the column, always keep the liquid oxygen pump going and the wash through the reboiler. We have held as long as 30 hrs. without finding contaminant build-up in hourly analyzing or with infrared monitorings.

MASON, Dow: I would like to ask the proper means of disposing of liquid oxygen when a river bank is not available. Our air plant is in a congested area. We must dispose of liquid oxygen at shutdowns even when the hydrocarbons concentration in the liquid in the column is not dangerous, because these concentrations might increase as the liquid oxygen evaporates. We now dump into an outdoor, covered aluminum tank having an 18 inch vent line extending above the roof. Has anyone had an experience indicating hazards or explosion possibilities in such a tank?

CULP, Grace Chemical: We considered a covered tank with a vent stack, but, on several of our gas vents, we have had minor explosions in the lines resulting only from atmospheric dirt. The biggest hazard of a covered tank would be the explosion possibilities from dirt, or a tremendous cleanliness problem.

COCHRANE, Sun Oil: We get the liquid oxygen out of the plant as quickly as possible during a shutdown, especially if the shutdown is caused by a high concentration of hydrocarbons in the oxygen. In an oil refinery we cannot use the French drain type of disposal. We have a remotely located tank into which we dump the oxygen. We have never found any problem in this type of arrangement. Almost all the oxygen vaporizes in the line going to the tank at high velocity,

less steel box with a 12 in. diam. stainless steel vent stack. It contains a flat plate heated from below by steam. The liquid oxygen draining out of the plant falls onto this heated plate. This vaporizer can take care of any normal purge rates. We find no evidence of oxygen enrichment around the stack which ends 12 ft. above ground. The oxygen drain tanks have been in service for five years. We open them once a year to check accumulated dirt. Up to now the only thing found was a silicate, which was probably due to dust blowing around the neighborhood.

CHAIRMAN WALTON: If you have a rapid drop-out, do you use this box too?

WEIGERS, Cyanamid: No. If we have to purge liquid rapidly we use the tank. The vaporizers handle more than 5 gal./min., and if we are in trouble, we like to get rid of it faster than that. We don't permit liquid to accumulate in this vaporizer.

BOLLEN, Dow (Canada): We were using a stainless steel tank located externally but adjacent to the air separation plant. The continuous oxygen purge was dropped into this tank and vaporized by a steam injector. The tank was vented to a 40 ft. stack running up along the air plant. However, the quantity of purge oxygen was too much for the steam vaporizer to handle with a resulting liquid level build-up in the tank and stack. This presented a hazard, in that we could have been concentrating hydrocarbons that might have been present in the liquid oxygen in the tank, and, therefore, a source of explosion next to the cold box. We have since discarded the tank and run copper lines from each of the purges to a cascade cooling pond about 80 ft. from the cold box. The pond water is about 15 in. deep, maintained by a weir. The oxygen lines discharge below the water surface, and the oxygen is vaporized by heat exchange with the large body of water. Since water flow from the cooling coils is continuous, the water in the pond is not cooled sufficiently to freeze.

CHAIRMAN WALTON: About a year and a half ago we had a shutdown where we emptied the cold box of rock wool, and the metal inspection people checked over every vessel and line. They reported there was no indication of pitting in any location. The thickness readings they got were equal to, or better than, the readings they took when the plant was installed. Since that was after three years service, they felt that we can go for another five years. If there are any indications then, they will insist that we cut open a manhead and go into one or more of the vessels to look. Does anyone else have different practices?

WEIGERS, Cyanamid: Our plant has

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where we do not have any problem of hydrocarbon deposition. A heater is not required in the tank itself. All the oxygen is vaporized within, say, two hours after the plant has stopped.

CHAIRMAN WALTON: How far is that from the nearest operating unit or storage tank?

COCHRANE, Sun Oil: About 100 ft.

WEIGERS, Cyanamid: We also have covered aluminum tanks. Open drain pits were used in our area for some time, but in Louisiana the ground pitch is minimal, and oil can float some distance during a rain storm. We devised a simple, effective vaporizer consisting of a stain-

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internal copper piping, and we operate in an area where the plant's central refrigeration system is also located. For the last year we have operated with a continuous trace of ammonia present in the intake air. When we shut the plant down for a scheduled derime, we ran the customary pressure tests to determine whether or not we had leakages and discovered a slight leakage beneath one of the regenerators in a small (98%) copper one-inch drainline, which was very brittle, paper-thin, and could be crushed in your hand. We sent a section to our metallurgical department to determine what happened. It looked like ammonia might have gotten down there during derime. We knew from temperature checks made during the derime that we had 40 or 50 lbs. of solid ammonia in our regenerators. We found that this line had failed in the same manner under each one of our regenerators. We have no idea why. I wonder whether anybody else has experienced a condition where copper turns brittle, possibly in the presence of ammonia.

CHAIRMAN WALTON: One of the questions still unanswered concerns velocities in oxygen piping. Someone mentioned 23 ft./sec. as European practice and he felt this to be a good maximum velocity.

Fires

CHAIRMAN WALTON: The last item on today's agenda is the Description and Analysis of Air Plant Fires. R. L. Shaner of the Linde Division of Union Carbide will discuss the recent Texas City fire.



Fahrenbruck Kenard King

SHANER, Linde: The March 30th Texas City oxygen plant explosion has been under intensive investigation. It has not been possible to reach definite answers to all that took place because of the extensive damage and lack of first-hand stories. However, some conclusions have been reached.

It is certain that although the explosion occurred in the oxygen plant building, it was not in the oxygen production equipment. Such equipment sustained only external damage due to flying debris, and has since been returned to production.

Evaluation of collected evidence indicates that the explosion resulted from ignition of combustible waste material, together with a high oxygen concentration in a covered trench.

Reconstruction of events before the accident shows that operators were draining liquid oxygen from one of two columns preparatory to thawing it out

for routine maintenance and inspection. This liquid was being drained into a disposal pit 135 ft. away through piping.

Phone contact with the operators about 3 min. before the accident indicated the operation was proceeding satisfactorily, although it was stated that the draining rate might have to be reduced. The operators had been provided with a schedule, and appeared to have been following this in correct sequence. After the accident, all the valves were found in proper operating positions.

The explosion centered in a covered floor trench carrying a 24-in. air line at about 80 lb./sq. in. gauge. The line used to drain high purity liquid oxygen from the column was also carried through a part of this trench out of the building to the disposal pit. However, the explosion center was in a portion of the trench occupied only by the air line (and a water line), about 20 ft. from the point where the liquid oxygen drain line entered the trench.

Metallurgical studies of fragments of the air line showed low temperature failure (below -60°F); indication that liquid oxygen entered the trench. We are forced to conclude there was a mechanical failure in the high purity liquid oxygen drain line, which let liquid into the trench. After the explosion, a break was found at one point in the drain line, and a damaged flange at another point, but whether these were "cause" or "effect" is undetermined.

The amount of contaminating combustible material in the trench before the accident is not known. A sample from the trench bottom after the accident showed 1.7% organic material dispersed on what was probably a mixture of powdered insulation and floor sweeping compound.

The ignition source is a matter of conjecture. It may have been low temperature failure of the air line, or handling of a trench cover plate by an operator sensing trouble. *The important point is that intimate contact of combustible material with a high concentration of oxygen had been inadvertently created.*

CHAIRMAN WALTON: The oxygen drain line was of what material?

SHANER, Linde: Aluminum.

KNAPP, American Messer: Has any estimate been made of the quantity of combustible materials present to create this effect?

SHANER, Linde: From the extent of damage it was calculated there would have been required about 20 lb. of liquid oil, or other combustible material in the explosion area.

CHAIRMAN WALTON: There was an explosion and fire at National Cylinder Gas in Conshohocken, Pa. next to the Alan Wood Steel Co. The gas plant supplied liquid oxygen across the fence to the steel plant and the difficulty started when a back pressure (diaphragm-type) regulator in the oxygen line caught fire. The reasons have not been established. There was no explosion or malfunctioning of the air plant

equipment itself. Does anyone have other incidents to report?

PERLEY, Canadian Industries Ltd., Montreal, Quebec, Canada: A year and a half ago we had a fire in a stainless steel, five-stage, high pressure oxygen pump with bronze impellers. The sustained combustion (stainless steel is not supposed to burn in oxygen) completely "gutted" the pump and destroyed the casings of two stages. We could not determine the cause. Our plant is in an agricultural area. We have never found trace acetylene in the oxygen, and we have exceedingly low total hydrocarbons.

Ammonia Plant Safety

CHAIRMAN WALTON: The first topic, Hydrogen Purification will be introduced by Gordon Weigers of American Cyanamid, New Orleans.

WEIGERS, Cyanamid: Some of the problems we faced and some solutions. The first is relief-valve fires—their prevention and control. Relief valves are not supposed to lift in a smooth operation, but we know that safety valves do lift, and that with the low energy required to ignite hydrogen, safety valve fires do occur. As long as the safety valve vent stack is in open air, these fires are not really a problem. By providing a means of injecting nitrogen into the valve stack, we can snuff out the fires.

Another problem is encountered during nitrogen wash unit startup. Large quantities of hydrogen-rich gas are vented and occasionally these vents ignite. We adopted a safe, simple solution. Dual vents are provided with means to inject nitrogen into either one. If one vent ignites, we switch to the other one, and blanket the culprit with nitrogen.

Another problem concerns hydrogen leaks inside the cold box, which creates a hydrogen-rich atmosphere. In the New Orleans area we average at least one summertime thunderstorm per day. We equipped our cold box with a steam snuffing system, and as a normal safety precaution, we turn on the steam to blanket the roof of the cold box whenever thunderstorms are imminent. We have been able to prevent fires along the seams of the cold box this way.

The problem of retention of low boiling point liquids for hydrogen purification units has again been placed on the agenda. In a nitrogen wash box the retention of liquids does not present the same problem as in an air separation plant. In this box you normally find hydrocarbons that would make an oxygen-plant operator's hair stand on end. The only problem in retaining these low boiling liquids (mainly nitrogen and CO) is to prevent the migration of solids deeper into the cold box while it is shut down. When forced down for any reason, we simply valve the box so that gases boiling off the liquid nitrogen pass back out of the box through the same circuits as the incoming raw gas uses. This way the solids deposited in the cold box are

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retained in areas where they don't cause problems. The rate of heat leak determines how long the liquid can be maintained; 24 hours is possible. If the shutdown time is longer we start losing our heat levels and then most of the liquid is gone. The deposited solids sublime and migrate deeper into the cold box, redepositing themselves in areas where you can't get rid of them. If the shutdown is so long that all the liquid inventory would evaporate, we have to derime the entire box if we intend to restart without excessive pressure drops in places where we are unable to cope with them.

Additional topics on this agenda are: the prevention of leaks; the detection of leaks; and once detected, how to repair them.

Unfortunately, it is difficult to build and operate a cold box that doesn't spring an internal leak sooner or later. A cold box has to be maintained under positive pressure and if the box is allowed to breathe, even a minor leak could result in a catastrophe. If the interior atmosphere of a box is kept free of oxygen, even major leaks can be handled safely. A major leak (large enough to interfere with the process) usually heralds itself by the appearance of ice spots somewhere outside the walls. The site of the spot is often enough to locate the leak. Unfortunately, it's not always so simple. We find it helpful to monitor the nitrogen we use to maintain a positive pressure in the box. Numerous sample points, judiciously placed throughout a cold box, help in spotting a leak and pinpointing its location. In one cold box we even provide each flange and instrument connection with its own monitoring, or sniffing connection. But even without such an elaborate system, careful analysis can pinpoint the location of a leak in 90% of the cases. We make routine explosimeter tests of our purge gas. It's important that the operators know the proper procedure when using an explosimeter in this particular service. The sampling gas is free of oxygen and the first deflection of the explosimeter needle is significant. As the sample gas is pumped through the meter, the oxygen present in the meter is displaced and the meter gradually drifts back to zero. An operator not familiar with this phenomenon could make a zero explosion-reading on a pure methane sample! Once a combustible material is found in the cold box, we run a complete gas analysis by mass spectroscopy or a gas chromatograph. Knowing the normal composition of various process streams and the composition of our purge gas, we can usually spot the leakage source even when there are two and three simultaneous leaks. With this sort of monitoring system, it should be possible to know just where to dig into the slag wool to take care of the leaks.

The most important factor in leak prevention is careful maintenance. We have tried torque wrenches when taking up on flanges, and have worked without them, without any definite conclusion.

We have adopted the policy of tightening major flanges once, cooling down the cold box without replacing the insulation, warming up the cold box, and tightening the flange once more. This is effective in getting tight closure on large flanges.

Instrument connections seem to be a major fault in internal leaks. Leaks can be reduced by supporting instrument lines on rigid supports. When installing instrument lines, extreme care must be used to provide proper expansion loops. A number of gasketing materials have been tried, including Flexitalic gaskets with Teflon or asbestos lining, or Teflon gaskets. We had good results with Garlock 900.

The problem of readying a cold box for maintenance: Most nitrogen wash plants are equipped with sparger pipe systems under the slag wool, which permit the nitrogen purging of the slag wool. Our box is so equipped and whenever we derime it in preparation for maintenance, we pass nitrogen through the process vessels, the piping, and through the slag wool. In this manner, most of the lighter hydrocarbons are displaced from the slag wool with little difficulty. However, on opening the cold box, we still find a positive explosion reading just about anywhere along the exposed face of the slag wool. We've probed to see whether this condition was general, and found to our surprise that this densely packed wool hinders diffusion of air through the mass. Explosive mixtures exist mainly along the face of the exposed wool. The hydrocarbons persist, but oxygen diffusion to create an explosive atmosphere is restricted. Despite this narrow band of explosive atmosphere, we do not permit hot work. Cold work is no problem, if maintenance people have adequate ventilation or air masks. We have soldered inside the cold box under these conditions, after the slag wool had been cleared from the work area and the area blanketed with asbestos; but we heated the soldering iron in a safe area away from the box, and then brought the hot iron inside. There is no safe way of doing hot work inside the cold box unless the slag wool is completely removed—a major undertaking. An alternate solution is to pass nitrogen through the slag wool to eliminate oxygen, but this presents serious problems in protecting maintenance men. They must work in masks, which appreciably slows maintenance work. On those occasions where we did hot work, we removed the piping sections to be worked on, to a safe area, did the work, and reinstalled them. The problem of flame propagation through slag wool enters this picture. Experi-

mental work along this line will be discussed later.

MASON, Dow: Many years ago we had several fires on outdoor vent lines from purge valves and safety valves at Midland. These fires were more frequent during static electric conditions, during thunderstorms, or when thunderstorms were impending. We suspected that static discharges were igniting the mixture and, on this basis, installed fiber tubes in the tees on the top of our purge lines. This reduced fires and worked well, until the fiber wetted and unwrapped in layers, ruining the insulating qualities of the fiber tubes. We then used Saran. The fires have not been completely eliminated. We still have steam snuffing connections in these places and we start a stream of steam into the line whenever the static conditions exist.

FUNK, German Linde: On the subject of rock wool as a flame-propagation deterrent, I would like to read a note by Dr. Karwat. For testing, we chose a container of about 7 cu. ft., filled with rock wool, and then displaced the air with a mixture of 2 volume-parts of hydrogen and 1 volume-part of oxygen. We left a 1-liter space in the middle of this box to ignite this explosive mixture with an electric spark. We discovered that the explosion occurred only in the void space. The explosive gas mixture was still in the wool, practically untouched. So we concluded that slag wool is the best agent to limit, or to block explosions.

In the slag wool packing of gas separation units we usually find a mixture of flammable gases, nitrogen, and some air, since a cold box cannot be built so tightly as to prevent air from entering through leaks in the shell after weeks, or months. Several thousand cu. ft. of air may penetrate the box from the top and leave through lower sections. If the shell is opened for maintenance, and slag wool removed to allow access for repairs, there would be a void space in which the gas-air mixture might ignite and explode. The heat would force the gas to leave the wool and to burn on the surface.

To extinguish flames with water would only promote the drainage of gas out of the wool. Therefore, before opening we suggest the box be purged with nitrogen, using a quantity five times the volume of the box. Later, the nitrogen can be displaced by air to allow the operators to remove the insulation.

MARTIN, Spencer Chemical: We consider relief-valve vent fires with a certain amount of favor. They have shown leaks we didn't know we had. When we started up we looked like the Fourth of July. We continue to fight leaks in a nitrogen wash cold box. We had a worse-

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than-average problem for a couple of years until we found two leaks in the (Trane type) switch exchangers. The leaks were in the external walls. Not knowing their cause, we'd been looking almost entirely at flanges. One more thing happened to us on two occasions. After purging the nitrogen-wash cold box with nitrogen, to what we considered a safe point, our operators descended into the cold box without masks. There was no oxygen and they had to be rescued.

KELM, Grace Chemical, Memphis, Tenn.: We had a five-foot void above the insulation level in the top of the cold box. To fill the box to prevent an explosive mixture, we purged with nitrogen until we had about 2% hydrogen concentration in the top of the box. Within half an hour after the explosion door at the top of the box was opened, there was a slight explosion, probably not severe enough to have lifted the door. At that time three nitrogen hoses were blowing into the top of the box.

It was a cloudy day, however, there was no lightning or apparent static condition. We were using ungrounded rubber hoses, but oscilloscope tests later did not show any static pick-up through the hoses. We still don't know just what did happen. The fire was snuffed very easily. The operator closed the explosion door and packed insulation around it, preventing more oxygen from entering the box.

Since then, whenever the box is opened, an analysis of the atmosphere for oxygen, hydrogen, and nitrogen is made immediately, and periodically.

BOLLEN, Dow (Canada): We have also done some work with flame propagation through rock wool. We made 22 duplicate tests in mixtures of hydrogen-air, ethylene-air, and hydrogen-oxygen-nitrogen, at concentrations corresponding to the highest flame velocities of these mixtures. Neither the ethylene-air nor the hydrogen-air mixtures produced flame capable of propagating through rock wool insulation at a depth of 4 to 10 in., and a bulk density of 0.9 to 15.3 lb./cu. ft. Flame propagation through rock wool was possible only with hydrogen-oxygen-nitrogen mixtures containing much higher oxygen concentrations than are present in air. The following conditions appear necessary for flame propagation: with 50% H₂, 37.5% O₂ and 12.5% N₂, the resulting flame propagated only through rock wool of a bulk density 9.48 lb./cu. ft. or less, or a thickness of 4 to 10 inches; with 50% H₂, 40% O₂ and 10% N₂, or any mixture with a higher oxygen to oxygen-plus-nitrogen ratio, the resulting flame propagated through rock wool insulation at a bulk density of 15 lb./cu. ft. or less, and a thickness of 4 to 10 inches.

CHAIRMAN WALTON: In some preliminary work we found hydrogen-air mixtures corresponding to the highest flame propagation conditions did not propagate flame through rock wool, but that hydrogen-oxygen mixtures did.

MASON, Dow: This problem of propagation through rock wool ought to be

taken with a grain of salt. In spite of the fact that rock wool may act as a flame retardant when packed at a certain density around pipe connections, the expansion and contraction of the equipment pushing these connections is likely to create a tunnel between the packing and pipes, which could serve as an explosion path, even if the packing around that tunnel might be a good flame retardant.

CHAIRMAN WALTON: That's true, it's almost impossible to prevent voids no matter how well the box is packed. On occasions we had our box repacked by the bidder and the results were bad. The last time we got the best people we knew, and it wasn't much better.

CLAPPERTON, Columbia-Southern Chemical Corp., New Martinsville, W. Va.: Our hydrogen comes from electrolytic chlorine cells. It is quite pure with the exception of some organic chlorides. We have operated our ammonia plant since 1955 without many problems, adsorbing the organic chlorides on activated carbon. However, this year we put mercury cells into service, and shortly had a problem we think is mercury contamination of our deoxo catalyst. We temporarily stopped using the mercury stream, but we are wondering what effect the trace amounts of mercury would have in the synthesis loop. Can mercury



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get beyond the main compressor? We considered that it would be trapped in the cooling sections around the compressor system. Since our main trouble started with deoxo-catalyst poisoning, we were not able to run long enough to determine the effects of mercury getting further into the system. Has anybody had experience along those lines?

BOLLEN, Dow (Canada): We use H₂ from both the diaphragm and the mercury-cell process. The mercury cells have been sending hydrogen to the ammonia plant since 1952. Since then we have noticed mercury in various compressor stages, but have never found it in the synthesis loop. In our first-stage intercooler we found the mercury had attacked the Admiralty brass tubes, causing embrittlement to the point where several tubes snapped off behind the tube sheet. Now the brass tubes have been replaced with stainless steel tubes, and activated carbon filters have been installed following the compressor stages to ensure the removal of the final traces of mercury.

FAHRENBRUCK, Columbia-Southern Chemical Corp., New Martinsville, W. Va.: What about discharge pressure of your compressor?

BOLLEN, Dow (Canada): Our final synthesis-gas pressure is 5,000 lb./sq. in.

In the intercooler the pressure is in the order of 35-40 lb. and most of the mercury is knocked out at that stage.

CLAPPERTON, Columbia-Southern: If you have a deoxo unit, what is its location relative to the synthesis compressor?

BOLLEN, Dow (Canada): Our deoxo unit is located immediately after the charcoal towers. We combine our electrolytic hydrogen with the synthesis-gas mixture we obtain from our nitrogen-scrubbing unit, and the combined stream is passed through the deoxo unit.

CHAIRMAN WALTON: I might give you a little of our philosophy on rock wool. After our experiments, we thought that if we had a leak in the box we could feel safe in living with it and continuing operation without an immediate shutdown. We agree with Mr. Weigers that we would not do any welding or hot work inside the box with the wool in there. We found that to purge the box properly, it is necessary not only to have spargers at the bottom but also at several levels up through the box. We have about five distributor pipes or spargers at three levels in the box, and we purge with a minimum of about 20,000 cu. ft./hr. of nitrogen. Before a shutdown, where we may want to go into the box for some reason, we usually step it up to about 40,000 cu. ft./hr. We have about 27 different points where we have probes in the box and every other day each point is routinely checked by operators with an MSA hydrocarbon detector, and a Fireite oxygen indicator for the percent oxygen present at that point.

HIMMELBERGER, Air Products: Have the experimenters noticed how slowly the flame propagates through rock wool? We luckily chose to use a glass tube to run some of our experiments and were able to see the flame move through the rock wool from a void at the bottom to a void at the top of the glass tube. It appeared that it took several seconds for the flame to travel through the bed. We took motion pictures of it. The flame propagated through an 18 in. bed, 2 in. diam., in $\frac{1}{3}$ of a second (six frames of 16 frame/sec. film). The rock wool was of relatively low density, although perhaps not much lower than you might find in some portions of a cold box. Also, the flame did not propagate through the mass of the rock wool, but definitely channeled, leaving charred trails.

BOLLEN, Dow (Canada): I can't answer your statement about speed because our tests were carried out in an enclosed tube, and I didn't carry out the experiments. Concerning hot work in cold boxes, we had a bad methane leak develop in our first nitrogen-scrubbing unit; the leakage dripping down the foundation of the cold box caused the foundation to heave, and the whole cold box gradually lifted approximately 8 in. When we got into the cold box, we found that one of the long lines (as Mr. Walton has mentioned) with an expansion loop in it had broken open at one of the welded seams, located near the top of the cold box. We cleared out the top third of rock wool

and spread fireproof blankets on the top of the rest of the wool, gas tested carefully, and carried out repairs. At that time, we had nothing like the experience we have today. I doubt that we would undertake such a repair job in the same manner again.

CHAIRMAN WALTON: We experienced a leak in the cold box and thought that it was a flanged joint about 2 ft. from the wall of the box. We opened the box at that point and dug the wool out while continuing to operate. We thought that probably all we'd have to do was tighten the flange studs. We uncovered that flange and there wasn't any leak there. There is another joint a little bit farther on, and in digging toward that, an explosion occurred, followed by two others. They were of minor intensity, but they did blow rock wool into the eyes of the repairmen. By talking to the men at the time of the explosion, we found that no one was poking in the box with any tools. We have made it a rule not to probe in the box while we're operating. We shut down and purge to a low hydrocarbon content before entering the box.

Does anyone have gasketing problems? On threaded joints we have found, Cyl-seal to be effective. It's made by the Westchester Chemical Co. It's good for oxygen lines too, as it contains no carbon-atom material. One thing with which we're particularly blessed is a scale model of our cold box that has been used many times in helping to determine where leaks might be, and how to get at them easily. Anybody contemplating an addition, expansion, or new cold box might consider that.

de PAUW, Carbochimique: Have any of you analyzed for the chlorine content of your synthesis catalyst after installing activated carbon adsorbers?

BOLLEN, Dow (Canada): We invariably find that there has been some poisoning by the chlorine. That is not an indication that our carbon filters are inadequate. In our process, part of the electrolytic hydrogen stream does not pass through the carbon filters, so some impure gas is going to our catalyst.

de PAUW, Carbochimique: We are using activated carbon filters on our whole gas stream and although we are not using hydrogen from chlorine cells, chlorine (coming probably from a water wash in previous stages in the gas-purification system) is going through the activated carbon-hydrogen purification equipment and is accumulating slowly in the synthesis catalyst.

CHAIRMAN WALTON: What kind of catalyst life are you getting under those conditions?

de PAUW, Carbochimique: We have been conducting these experiments on a systematic basis only for the last 1½-2 years. Actually, we replaced our catalysts at the end of 1956, on a routine change, so we have had only enough experience to know that the catalyst is doing very well although the chlorine content is increasing.

BRUNI, Soc. Edison, Porto Marghera, Italy: We have a mixture of 80-85% hydrocarbon from natural-gas reforming, and 15% hydrogen from chlorine manufacture. We have found, after two years, a great quantity of chlorine in the synthesis catalyst. Our silica gel adsorbers are not sufficient. At what temperature do the activated carbon adsorbers operate in your plant?

BOLLEN, Dow (Canada): Our carbon towers are located after the compression stages. However, the gas from the compressor aftercooler knockout pot is pre-heated to approximately 120°F before it enters the carbon tower.

CLAPPERTON, Columbia-Southern: Our carbon adsorbers are actually on the hydrogen stream as it comes from the chlorine plant. Various analyses indicate there are 5-10 p.p.m. organic chlorides (expressed as HCl) entering these adsorbers. We operate them at a little higher than ambient temperature, and the exit chloride content probably averages about 0.1 p.p.m., sometimes less. We have found some chloride depositing on our deoxo catalyst, ahead of our main compressor in the ammonia plant. We also find traces of chloride in our ammonia product. We have not checked our synthesis catalyst, but assume that chloride is there since we do find some in the ammonia.

FAHRENBRUCK, Columbia-Southern: I might add that we have had the plant on stream 3½ years and have detected little loss of catalyst activity, so apparently the chloride isn't affecting us too much.

SANDERS, Texas Co.: We had occasion to do some hot work a few feet inside the cold box during a downtime when the box had been purged with nitrogen for a week after the unit was down, but we still detected hydrocarbons there. We lined the tunnel we made with polyethylene sheeting and taped it with masking tape all around the lines going into the box. We turned on a blower in the tunneled area and, (with continuous gas testing) did some Heliarc welding. We and our safety and maintenance people considered it safe.

CHAIRMAN WALTON: Did you supply the area with nitrogen?

SANDERS, Texas Co.: No, we used an air blower into the area where the hot work was done, and nowhere over that whole area did we have any indication of hydrocarbons.

CHAIRMAN WALTON: Had you warmed up the box before?

SANDERS, Texas Co.: Yes.

CHAIRMAN WALTON: That's always a problem; whether you dare go in without warm-up because, on a moist day condensation in the wool will eventually build icebergs. When we completely removed the wool from our cold box a year and a half ago, there were some large icebergs in it as a result of the burrowing. I have worried about the building up of such things and their resultant strains on piping, and so on.

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So, it seems there's always a calculated risk when you go into a cold box.

LAWRENCE, U.S.I.: I had the dubious distinction of being inside the box when it caught on fire one time. We were doing some welding and had about 30,000 ft./hr. of purge on the box. We'd been purging for about two days and had taken normal precautions. We had the normal insulation dug out and had it blanketed between us and the insulation, and had a blower supplying fresh air. The nitrogen was coming out in a pretty good stream, the welder was welding merrily away. Our flame checks had been good up to that point. For some reason, we evidently had some heavy hydrocarbons at the bottom of the box that the purge apparently started picking up. Suddenly, about 6 ft. from where the gas was leaving the insulation from under the tarpaulin, it ignited. There we were sitting—the torch on, and the fire burning alongside. We turned off the torch and grabbed insulation and stuffed the hole where the purge was coming out. This stopped the fire. But we decided we would never weld in the cold box again, anywhere near the insulation.

At times we've been able to take the paneling off the box and see cracks in the edge right into a cold vessel—slightly hard on refrigeration, so we've replaced the paneling with stainless steel and sealed the box. Before that, we actually had holes in the top, so our box is full of ice. We've worried about stress on pipes and voids in the ice.

Since we've put the stainless steel paneling on, we've carefully carried out a box sealing program. This is to go over the box with sealing compound and continually seal every little exit except the roof vent. We normally run with 15,000 ft./hr. of nitrogen purge in the box and the only thing we get out the roof vents is nitrogen, plus our leaks.

CHAIRMAN WALTON: This business of sealing the box is really a problem. We've gone over our box several hundred times, and do it continually, yet there are leaks that you just can't find. Even with 40,000 cu. ft./hr. of nitrogen in the various purge lines, you can't detect any velocity in the roof vents.

Gas reformer furnaces

MAUNE, Mississippi River: My experience has been with the low-pressure reformers at TVA. They were the revised design of the Chemico round-type furnace. There were four units in operation. Each furnace had 20 tubes in cross pattern with 5 tubes to each quadrant. It has always concerned reformer operators that leaks might occur in furnace tubes and flanges, or that tubes might rupture.

The temperature control was easily managed. The tube skin temperatures could be easily maintained within limits,

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if catalyst could be contained in the tube. The general design was a type 310 stainless steel tube, about 21 ft. long and 8 to 10 in. in diam. A smaller inside tube of about 2-in. diam. made an annular space in which the catalyst was placed. The bottom of the inner tube was held in place by an engaging sleeve coming up through the bottom flange. During startup several of those tubes were not engaged, so that as soon as enough pressure-drop across the catalyst bed occurred, the catalyst would sweep out of the tube and end up in the secondary reformer. Of course, this took time. The catalyst would break up, resulting in a hot furnace tube—a readily noticeable condition. However, the furnace operated under these conditions for about a week without any damage, after which the unit was taken down and proper repairs made.

To control the furnace tube temperatures in this particular installation, there were balancing valves for each set of tubes, and each tube inlet had a restrictive orifice of a size calculated to permit even gas distribution to all the tubes. The orifices were important, as demonstrated on one occasion when one of the orifices was plugged with gravel left in the piping during construction. This restricted the gas flow to the tube, resulting in a hot tube. We never experienced ruptured tubes or flange leaks which could catch fire inside the furnace. Actually, the flanges on this particular tube are not inside the furnace. The bottom flange was outside, on the bottom of the furnace and covered with a protective hat, not really in a hot zone. Also, the top flanges, which included the inlet and outlet gas from the tube, were not in the fire zone.

KENARD, Selas Corp. of America, Los Angeles, Calif.: We have supplied to Best Fertilizer a steam methane reforming furnace. This heater has no bottom flanges on the tubes. We supply a case fitting, welded on the bottom of the cast stainless tube by the tube supplier in the shop. The upper inlet end of the tube is a conventional flanged inlet, but the hot outlet (I believe the temperature is 1450°) is a cast fitting. A pigtail connection leading out of this cast fitting is welded in the field. The pigtail connection leads down to an outlet manifold header, where the outlet gases are accumulated.

This steam methane reformer furnace uses the principle of the Gradiation heater that we have successfully applied to the cracking of ethane and propane. Selas Duvadiant burners, used in this heater, are radiant burners with no flame in evidence in the firebox of the heater. The flame is contained within the burner cup. It's a pre-mix type burner with no secondary air required. Consequently, we are able to control the heat distribution to the tubes by using a multitude of these burners, in horizontal and vertical rows, giving even heat distribution through the firebox. The Best unit

operates at a pressure of 120 or 130 lb. Inlet temperature to the tubes is about 700 or 750°, outlet temperature, 1450°. **SZE, Hydrocarbon Research:** Has the Selas furnace been in operation for some time, and if so, have there been any tube failures?

ANONYMOUS, Selas: The only other steam methane reforming furnace we have in operation is in Germany and, unfortunately, I'm not qualified to comment on it. The Best Fertilizer unit will be in operation probably by the middle or latter part of November (1958-Ed.). **KING, Sohio:** We operate a high-pressure reformer furnace and have operated for three years with no tube failures. We have some 336 S.S. 3-in. Incoloy tubes with external flanges, and inlet and outlet pigtail on each tube. The failure problem has been in the pigtail weld made in the field. We had about 30 failures in our first year of operation. The wide distribution of gases through a large number of tubes did not result in any serious fires from any of the failures. Has someone an experience with tube elongation as a result of continued operation?

WHITE, San Jacinto: We have a low-pressure unit in operation about 15 years. The tubes have stretched about 3 in. **CHAIRMAN WALTON:** What was the material?

WHITE, San Jacinto: It's an old Hercules furnace, very high in nickel. When we started operating these back in '50, we weren't careful to compensate for elongation of the spring suspension of the tubes from the top. They elongated to a point where the bottom flanges started to build up tension and the tubes warped considerably before we found the trouble. By correcting the spring tension, we practically stopped all troubles.

CHAIRMAN WALTON: Did you have to replace any of the tubes because of distortion?

WHITE, San Jacinto: No. A year and a half ago one of them failed in front of one of the burners but we patched it. So far it has not leaked again.

CHAIRMAN WALTON: You repaired a crack by welding it?

WHITE, San Jacinto: We repair all our cracks by welding with stabilized 310 welding rod. A number of the original welds which have failed, we repaired right in place.

deVRY, Hercules: We guard against tubes breaking inside furnaces by having a 1-in. connection and valve on top of each tube. A steam outlet at the top of the furnace can be quickly connected to one of these valves. Should a tube rupture, there is a large evolution of gas and an impingement of the flame upon the furnace wall. The operator is warned as the temperature rises on the wall thermocouples. He then goes to the top of the furnace, connects the steam hose to the appropriate tube, and blankets the tube with steam, forcing out the flame. The steam prevents backflow of cracked

gas from the other tubes of the furnace and also keeps the natural gas from coming in at the top. You can operate with a ruptured tube for some time in this manner.

On the attainment of even distribution of gas in furnace tubes, we found it wasn't too easy to valve-off certain tubes to force the gas into the other tubes. To let the distribution take its normal course, it will follow into the tubes with the least resistance. The critical thing is the grid support at the bottom of the tube on which the catalyst rests. Often this gets plugged, and one tube resistance might be $\frac{1}{2}$ lb./sq. in. more than some of the other tubes, and the tube will run hot. We try to have an open grid at the bottom and have all the tube resistance in the catalyst packing, itself, by trying to obtain uniform packing. We don't just dump the catalyst in; it is lowered in a loading device and spread in the tube.

In taking a shift converter out of service, we use the relatively pure CO₂ available from our CO₂ scrubbing system and pipe it to each of our individual shift converters. We isolate the converter with respect to the gas stream, admit the CO₂, and exhaust the outlet gas to the atmosphere. That way, we can safely lower the temperature without runaway heating. This also preserves the iron-oxide catalyst in its lowest oxidation state and gives a good cooling and tempering job on the catalyst.

When we shut down our reforming furnaces we allow the steam through the tubes until the tube walls are down to about 800°F, measuring tube-wall temperatures with an optical pyrometer through ports along the furnace wall.

STOCKBRIDGE, Southern Nitrogen: In reference to this loading device, what size are the tubes?

deVRY, Hercules: 8-in. tubes, 24 ft. long. The loading device is about 7½ in. diam.—a close fit in the tube. It can't be used in badly warped tubes. It has a vane at the bottom tripped by the weight of the loader as it comes to rest on the catalyst in the tube.

MORRIS, Texas Eastman: Have you no orifices in the inlet of the tube? Do you just let the pressure drop of the individual tube take care of the flow through the tube?

deVRY, Hercules: We tried orifices but had little success with them.

ANONYMOUS: We think we get better distribution through our ring-type catalyst than through a solid type.

CHECKSFIELD, Air Products: What tube life has Sohio had with the Incoloy tubes at 125 lb./sq. in. pressure? There is controversy over Incoloy tubes.

KING, Sohio: We have had no tube failures nor indication of elongation during three years of operation. These tubes are 3-in. O.D. and about 40 ft. long. We have removed and replaced the catalyst, and to get distribution through the 336 tubes, we carefully weigh the amount of catalyst going into each tube.

Part 3 will appear in the August issue of CEP.

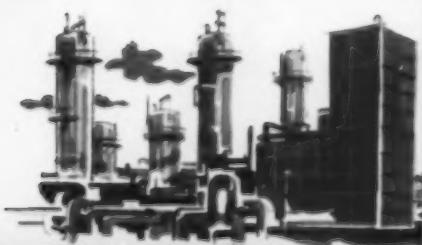
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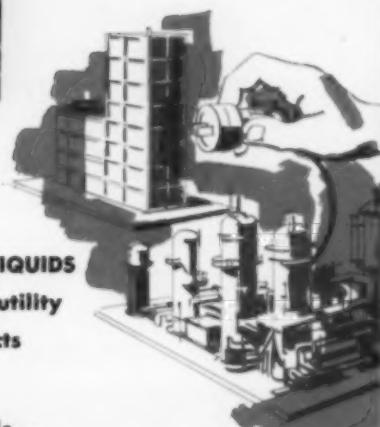
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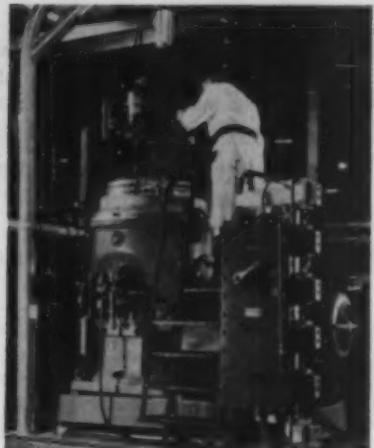
Large titanium, tantalum, zirconium equipment now available. New talents and welding methods like inert gas chamber shown now make it possible to specify large Pfaudler vessels 134

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COMPUTER PROGRAM abstracts

The Machine Computation Committee of the A.I.Ch.E. is interested in receiving program abstracts covering the following:

Chemical Engineering

The primary field of interest is chemical engineering computer programs of design and engineering nature.

Other Branches of Engineering

Programs in other branches of engineering are of interest as they relate to general design problems in the petroleum and chemical industries.

Applied Mathematics

Computer programs such as convergence techniques, differential equation solutions, and other mathematical treatments related to solution of engineering problems.

Reservoir Engineering

Programs relating to petroleum production engineering.

Statistical Analysis and Control of Operations

Analog Techniques

Programs such as analog techniques for surge vessel design.

Computer Control of Processes

Once again the Committee wishes to emphasize the three rules for participation in the interchange program:

1) Abstracts submitted for publication must follow the form published in *CEP* (January, 1959) and in the *Guide*.

2) Abstracts must be sent to the Machine Computation Committee c/o A.I.Ch.E.

3) All questions relating to published abstracts must be sent to the Committee c/o of A.I.Ch.E. in New York.

Non-linear estimation (016)

G. W. Booth and T. I. Peterson

IBM, Data Processing Division, Mathematics and Applications Department

White Plains, New York

Description: The program treats the following statistical problem. Given a functional relation between a single dependent variable and a set of K independent variables and P parameters, and given data for N observations of the dependent variable and NK corresponding values of the independent variables, provide: (1) estimates for the parameters by an iterative least squares procedure and (2) information to assess the worth of the estimated parameters. The functional relation may be linear and/or non-linear in the parameters as well as the independent variables, and may be explicit or implicit, the necessary condition being that it admit of numerical

evaluation. The program may be used for the case of more than one dependent variable. It is based on methodology developed by G. E. P. Box, Director of the Statistical Techniques Research Group, Department of Mathematics, Princeton University.

Computer: IBM 704, 8K core.

Program language: SAP

Running time: Computational time is dependent on many factors. A moderate problem ($N = 25$, $K = 3$, $P = 5$) requires about one minute per iteration for an explicit function, and approximately three times as long for a function requiring the solution of differential equations.

Comments: The program has been used in scientific and business problems of various types. Of considerable interest is its application in chemical reaction kinetics where estimation of reaction velocity constants and evalua-

tion of the mechanism of the reaction is under study. Information provided by the program includes: (1) least squares estimates of the parameters and (2) data for: (a) analysis of the residuals, (b) analysis of the correlation between estimates of the parameters, (c) a check that the least squares estimates truly correspond to a local minimum, (d) evaluation of the linearity of the functional relation with respect to the parameters in a local region, (e) analysis to determine the local nature of the minimum, and (f) approximate confidence regions for the estimated parameters.

Availability: The manual for this program can be made available for publication by August 1, 1959.

Humble plate-to-plate distillation procedure for conventional and complex columns (017)

W. N. Lyster

Humble Oil & Refining Company, Technical Division, Baytown, Texas

Description: The program performs a complete plate-to-plate distillation calculation with heat and material balances. A modified Thiele and Geddes method of calculation is used. In this method, a temperature is assumed on every plate, compositions are calculated, and heat and material balances are made to obtain the vapor and liquid rates on each tray. After each trial, the tray temperatures are adjusted and the vapor and liquid profiles are recalculated. When the desired specification is obtained, the calculation is terminated. All assumptions and adjustments made before and during the calculation are automatic.

The program is designed to handle as many as three feeds and five side-stream draw-offs. Both liquid and vapor distillate streams may be specified either separately or in combination, but the bottoms product must always be a liquid at its boiling point. The sidestream withdrawn from a particular tray in the column may be liquid or vapor. A maximum of twenty-one components and one hundred theoretical plates may be specified. In general, the input data and specifications required are:

1. A composition, rate, and condition for each feed.
2. Enthalpy and equilibrium data.
3. Tower variables (vapor rate limitation, feed tray locations, sidestream locations, total number of theoretical trays).
4. Distillate condition and side-stream conditions.

continued on page 92



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QUICK ACCESS LOOP: 64-word recirculating register for parallel input, computation, and output.

SPEED: 66 samples per second.

NUMBER: 8, expandable to 512 with additional optional plug-in components.

SEQUENCE: By computer command; changeable by program.

VOLTAGE RANGE: 0-1 and 0-10 (or more) volts d.c.

MANUAL: Flexowriter and punched paper tape.

DIGITAL CLOCK: Internal, pure binary, real time to provide time of day for logging.

OUTPUTS

Flexowriter and punched paper tape; and computer logic producing 10-bit addressable word to actuate relays for control signals.

SPEED AND NUMBER: 66 outputs per second; time-sharing permits unlimited number.

SEQUENCE: By computer command; changeable by program.

TIME READOUT: From digital clock.

TYPICAL OPTIONAL CONTROL FUNCTIONS AVAILABLE: Alarms, voltage level, bridge balance, relay closure, setpoint, reset rate, proportional band, variable time delay, recorder, plotter.

GENERAL SPECIFICATIONS

COMPUTER TYPE: General-purpose digital.

NUMBER BASE: Binary.

MODE OF OPERATION: Serial.

INSTRUCTION TYPE: Single address.

NUMBER OF DIFFERENT INSTRUCTIONS: 16

MEMORY TYPE: Magnetic drum.

MEMORY CAPACITY: 4096 words.

WORD LENGTH: 30 bits plus sign.

CLOCK FREQUENCY: 136 KC

ADD TIME (Excluding Access): 0.25 milliseconds.

MULTIPLY TIME (Excluding Access): 15 milliseconds.

WEIGHT: 1000 lbs. nominal.

SIZE: 30" x 42" x 60".

POWER REQUIREMENTS: 117 volts ($\pm 10\%$) 17 amperes 60 cycles.

OPTIONAL EQUIPMENT

PHOTOELECTRIC READER: High-speed punched paper tape input for buffer storage.

MAGNETIC TAPE: Storage for additional input, output, and computing information.

MAGNETIC-CORE MEMORY: For quick access to stored data.

PUNCHED CARD INPUT.

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GRAPHIC PANELS: For visual display of information.

CONSTANTS PANEL: Manual digital data insertion or readout for operation by non-technical personnel.

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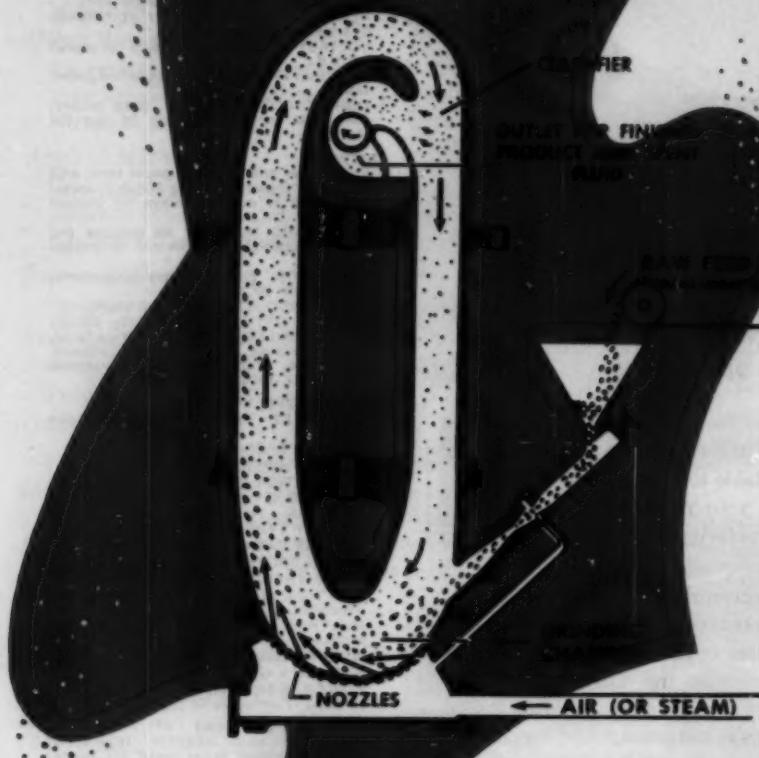
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Computer programs

from page 90

5. Specified product rates (distillate, sidestream, and bottoms).

Computer: IBM 705, 40,000 memory, 1 drum, 4 tapes.

Program language: Autocoder.

Running time: In general, running times vary from 0.3 to 0.4 seconds per component per plate per trial. A normal problem will require approximately eight trials to converge.

Comments: The answers which are normally printed include a final heat balance, a final material balance, and temperature, liquid and vapor profiles. On option, liquid and vapor compositions on every plate may be printed out. The program is also equipped to correct equilibrium data for the effect of composition by the use of binary-type activity coefficients.

Availability: The manual can be submitted for publication by Jan. 1, 1960.

Liquid-liquid heat exchanger design (O18)

D. J. Hartline

*Esso Research & Engineering Co.
Linden, New Jersey*

Description: This program will do essentially the complete process design, including nozzle sizing, of a shell-and-tube heat exchanger or cooler, with liquid on both shell and tube side. It can also be used to calculate the pressure drops and over-all coefficient in checking an existing exchanger for a new service. The program uses standard methods.

In addition to normal required input of fluid properties, rates and conditions, the engineer may specify: maximum allowable area per shell; tube length and diameter; minimum and maximum allowable tube side velocity; minimum shell side velocity; maximum and minimum baffle pitch; square or triangular tube pitch; vertical or 45° angle baffle cut and fouling factors. In addition, two values each of maximum tube side pressure drop and shell side pressure drop may be specified. Program will design an exchanger for the four possible pressure drop combinations.

A more detailed description of the program, and a simplified logic diagram, is given in the paper, "Engineering Design on a Computer", by E. J. Higgins, J. W. Kellett and L. T. Ung, *Industrial and Engineering Chemistry*, 50, 712-718 (May, 1958).

Computer: IBM 650.

Program language: Humble Interpretive System No. 2.

Running time: 10 to 45 minutes.

Comments: Program has been used satisfactorily hundreds of times for heat exchanger design.

Availability: A manual on this program will be submitted for publication in about two months.

Multicomponent distillation (020)

A. K. Mills

The Dow Chemical Company, Computations Research Laboratory
Midland, Michigan

Description: This program is a multicomponent, tray-by-tray calculation with a heat balance around the column and around each tray. It is limited to single feed columns with no sidestream draw-offs. It can handle up to 10 components in non-ideal mixtures. Non-volatile non-condensable components can be included in the feed, and the condenser may be specified as total or partial, or as providing cold reflux.

The input data consists of the usual column parameters and operating variables, the stream compositions (specified or estimated), Antoine con-

stants for vapor pressures or K-values, molal heat capacities if available, and one or two binary interaction constants for each binary pair as defined in the Redlich and Kister expression for liquid phase non-idealities.

Any one of three results can be obtained:

1. The component distribution in the distillate and underflow for a fixed number of theoretical trays, a fixed feed location, a specified reflux ratio and fixed draw-off rates.

2. The reflux ratio required to obtain a specified "split" between "key" components for a fixed number of trays and a fixed feed location.

3. The "best" feed trays; defined as the feed tray which gives the smallest reflux ratio to obtain a specified "split".

Complete output of column conditions is obtained with all three types.

Computer: Datatron 204 or 205 (4080 words of storage) with floating point hardware and a choice of paper tape or PCC 500 (for punched cards or line printer) required for input and output. (Magnetic Tape permits multiple problem input-output but is not required by the program proper.)

Running time: Time varies with problem. Minimum is 2 or 3 minutes for only 3 or 4 components on only 3 or 4 trays. Maximum can be over an hour for problems with severe non-idealities and a large number of trays. The "best" feed tray result runs 2 to 4 times as long as the other types of problems.

Comments: The program may require manual intervention to alter a convergence constant in some cases. The program is written to make this intervention as simple as possible. Only problems with severe non-idealities frequently require intervention.

The program consists largely of self-contained subroutines for the various bits and pieces of the calculation. These subroutines have been very widely used to construct a great many programs for special distillations and problems involving or related to distillation.

Availability: A complete program manual will be made available through the A.I.Ch.E. if requests warrant it. Operating decks are immediately available with some options for input and output.

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For more information, turn to Data Service card, circle No. 87

Corrosion resistance of titanium alloys

A comparative study of the most commonly used commercial titanium alloys in a variety of corrosive media.

Corrosion resistance of commercial titanium base alloys has been investigated in an intensive program at Battelle Memorial Institute, under the sponsorship of Mallory-Sharon Metals.

Alloys tested are listed in Table 1, together with the chemical analysis of each alloy. All alloys were in the form of 0.040 in. hot-rolled sheets. The heat-treated sheets, as supplied to Battelle, had an acid-pickled surface. However, corrosion tests were conducted on both the as-received specimens and on specimens polished by wet grinding with 240-grit paper. The corrosion media used are shown in Table 2 along with other test conditions. These media were selected to include those in which commercially-pure titanium is completely resistant, partially resistant, and non-resistant. In most cases, tests were run for 336 hours, except that, where corrosion rates were high, the tests were sometimes stopped after 24 or 48 hours.

Hydrochloric acid

In 1% HCl at 190°F, all the alloys except MST 6Al-4V, MST 5Al-2.5Sn, and MST 185 had excellent corrosion resistance. In 3% HCl at 190°F, corrosion rates were excessive for all the alloys, with MST 5Al-2.5Sn and MST 185 having the highest rates, and MST 3Al-2.5V the lowest. In neither the 1% nor the 3% acid at this temperature did there appear to be any consistent effect of surface finish (pickled vs. polished) on corrosion rate. In most cases, the effect of surface finish was negligible.

In 3% HCl at 95°F with air agitation, all the alloys had excellent corrosion resistance except MST 5Al-2.5Sn and the as-pickled specimens of annealed MST 6Al-4V. With nitrogen agitation, rates were generally much higher. It appears that, in HCl solution, the passivity of most titanium alloys is dependent on the dissolved oxygen content of the solution. The corrosion resistance of annealed MST 6Al-4V is quite sensitive to surface condition, since the as-pickled specimens corroded at much

higher rates than did the mechanically polished ones. The same was true for MST-70 when nitrogen agitation was used.

In 5% HCl with air agitation, corrosion rates for the polished specimens were rather erratic, particularly for MST 2.5Al-16V and MST 185. The as-pickled specimens, in general, corroded at higher and more consis-

tent rates. The MST 3Al-2.5V alloy was completely resistant in both surface conditions. The effect of nitrogen agitation varied with the different alloys. Some (MST 8Mn, MST 6Al-4V) corroded at lower rates with nitrogen agitation, while others, notably MST 3Al-2.5V, corroded much faster with nitrogen agitation.

continued on page 96

Table 1. Chemical analyses of alloys used in corrosion tests.

ALLOY	O ₂ %	N ₂ %	C %	H ₂ %	Fe %	Al %	V %	Mn %	Sn %	Cb %	Ta %
MST-70	0.204	0.017	0.11	0.0073	0.27	...	...	...	...	...	...
MST-8Mn	0.007	0.01	0.04	0.0082	0.13	...	...	8.2	...	...	...
MST 6Al-4V ⁽¹⁾	0.059	0.011	0.04	0.0031	0.20	6.27	4.21	...	...	...	...
MST 6Al-4V ⁽²⁾	0.081	0.009	0.03	0.0057	0.18	6.08	4.50	...	...	...	...
MST 5Al-2.5Sn	0.142	0.02	0.02	0.0032	0.19	5.00	...	...	1.99	...	...
MST 821	0.101	0.015	0.02	0.0062	0.20	2.25	7.96	...	...	3.25	1.01
MST 2.5Al-16V	0.093	0.015	0.04	0.0130	0.20	2.85	15.94	...	...	...	...
MST 185	...	0.004	0.02	0.0084	5.09	1.76	7.28	...	...	...	...
MST 3Al-2.5V	0.120	0.011	0.06	0.0020	0.17	2.91	2.45	...	...	...	...

⁽¹⁾ Annealed specimens (Heat No. 25586).

⁽²⁾ Age hardened specimens (Heat No. 22583).

Table 2. Media and conditions of tests.

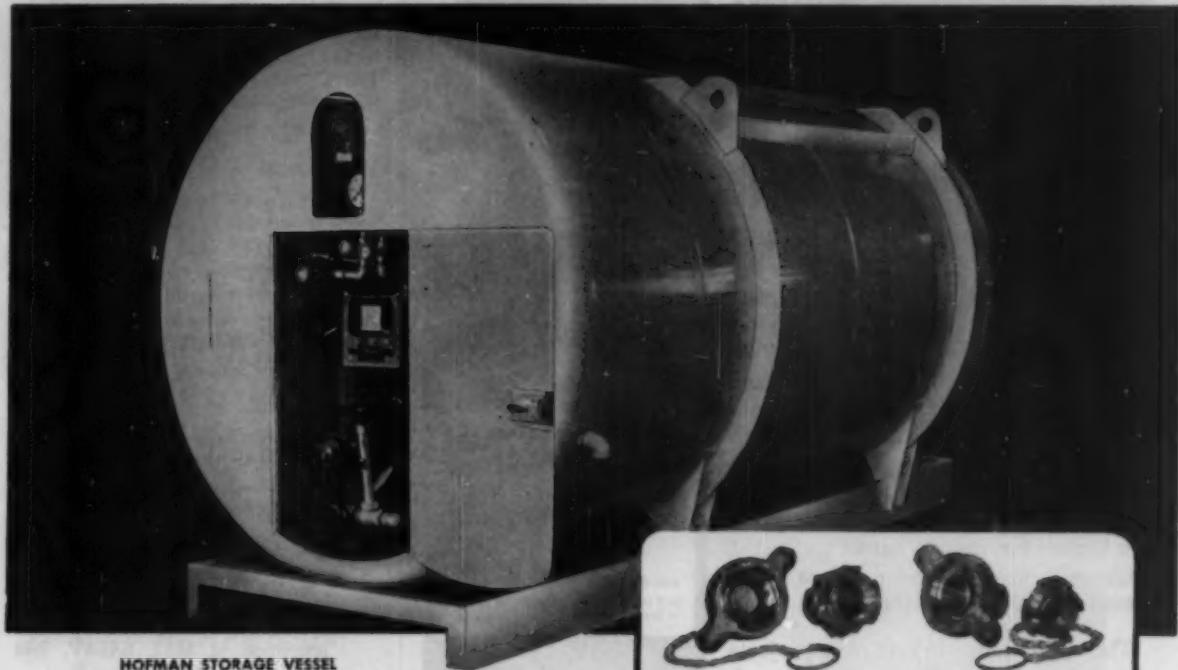
CORRODENT	CONCENTRATION %	TEMPERATURE °F	AGITATION
Hydrochloric Acid	1	190	None
	3	190	None
	3	95	Air
	3	95	Nitrogen
	5	95	Air
Sulfuric Acid	5	190	Nitrogen
	5	95	None
Oxalic Acid	5	190	Air
	5	95	Nitrogen
	5	95	None
Formic Acid	25	190	Air
	25	95	Nitrogen
	25	95	None
Aluminum Chloride	25	190	None
	25	190	Air
Ferric Chloride	25	190	Nitrogen
	25	95	None
	25	95	Air
Sodium Chloride	Saturated	190	Nitrogen
	Saturated	95	None
	Saturated	95	Air
Sodium Hydroxide	25	190	Nitrogen
	25	95	None
	25	95	Air

* Weight Per cent.

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Titanium alloys

from page 94

Sulfuric acid

In 5% H_2SO_4 at 95°F with air agitation, lowest corrosion rates were observed for MST 70, MST 3Al-2.5V, MST 185, and solution-treated MST 2.5Al-16V. Effect of nitrogen agitation was again somewhat erratic, but in most cases, corrosion rates were higher than with air agitation. At 190°F, rates were excessive for all the alloys, with MST 5Al-2.5Sn again corroding at the fastest rate.

Oxalic acid

In 5% oxalic acid at 95°F, rates were lowest for MST-70, MST 2.5Al-16V, MST 185, and MST 3Al-2.5V. Type of agitation and surface finish had little effect in most of the tests. At 190°F, rates were excessive for all alloys, with the highest rate observed for MST 5Al-2.5Sn.

Formic acid

In 25% formic acid at both 95°F and 190°F, all the alloys were completely resistant, with only the following few exceptions:

- 95°F, N_2 agitation—MST 6Al-4V, 5 mils/year
- 95°F, N_2 agitation—MST 8Mn, 5 mils/year
- 190°F, no agitation—one as-pickled specimen of MST 6Al-4V, 164 mils/year
- 190°F, no agitation—one as-pickled specimen of MST 2.5Al-16V, 50 mils/year.

Aluminum chloride

Tests in 25% $AlCl_3$ solution at 190°F, were extremely erratic. While some tests showed negligible corrosion, other tests showed rates as high as 150 mils/year for the same materials. It is believed that these results are due to the instability of the solution at the test temperature, since aluminum chloride hydrolyzes in water to form aluminum hydroxide and hydrochloric acid. However, the tests did indicate that, under certain conditions, aluminum chloride solutions will severely attack titanium and its alloys.

Ferric chloride, sodium chloride, sodium hydroxide

Under the test conditions, all the alloys were completely resistant to these solutions.

Overall conclusions

- In strong acids, the titanium alloys

continued on page 99

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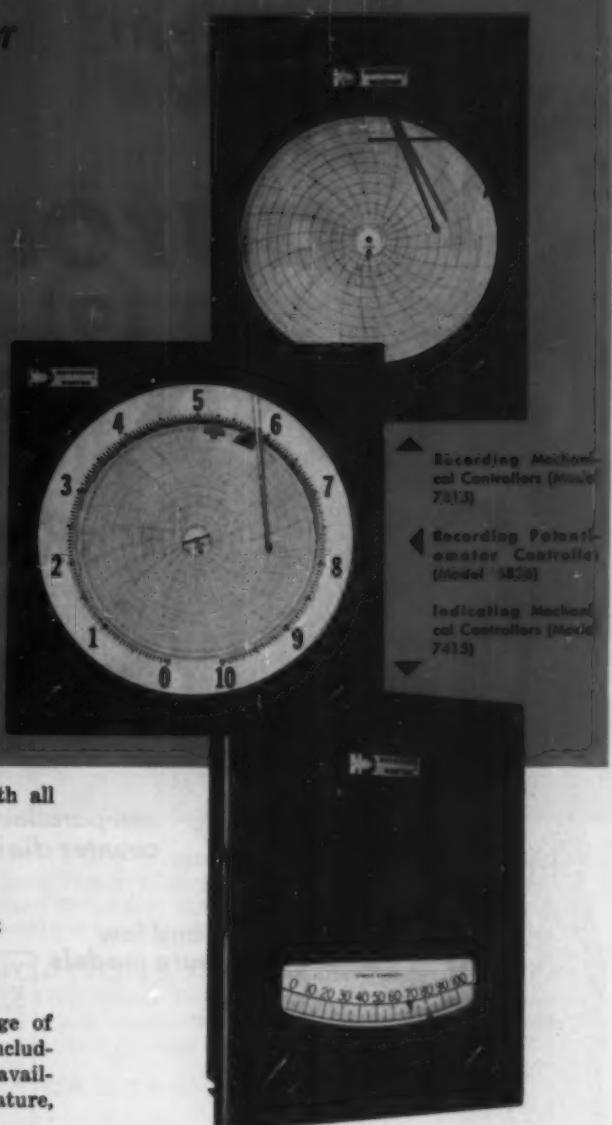
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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959 97



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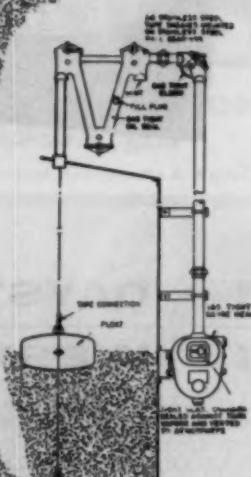
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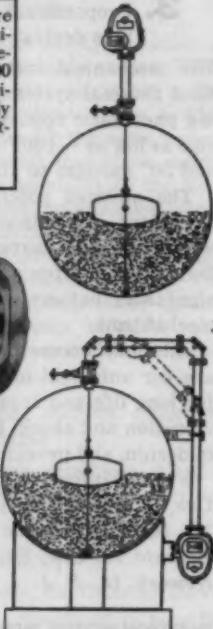
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Titanium alloys

from page 96

are less corrosion resistant than commercially-pure titanium, with the exception of MST 3Al-2.5V, which is about the same as commercially-pure.

• All alloys tested are completely resistant to ferric chloride, sodium chloride, and sodium hydroxide solutions, under the test conditions.

• Under certain conditions, solutions of aluminum chloride can severely attack titanium and titanium alloys.

• In the MST 2.5Al-16V, MST 6Al-4V, and MST 185 alloys, different heat treatments have no great effect on corrosion resistance.

• In most cases, mechanically polished specimens are more corrosion resistant than specimens having a pickled surface finish.

• A plentiful supply of oxygen in the solution reduces the corrosion rates of titanium and its alloys in acid media.

• An approximate rating of the alloys tested, from most corrosion resistant to least corrosion resistant is:

1. MST-70, MST 3Al-2.5V
2. MST 2.5Al-16V
3. MST 821, MST 8Mn
4. MST 185
5. MST 6Al-4V, MST 5Al-2.5Sn

Members of A.I.Ch.E., along with twenty other engineering societies, can now attend general meeting of ASME without registration fees. This latest step toward unity of the engineering profession at the working level was taken under an arrangement made by ASME. The twenty-one groups represented on the Engineers' Joint Council and the Engineers' Council for Professional Development can, in addition, attend conferences sponsored by ASME's professional division at the same fee charged to members.

Capacity for production of polyethylene has been increased from 85 to 100 million pounds annually at Texas Eastman Co. in Longview, Texas. The company, a division of Eastman Kodak, has steadily stepped up its output of polyethylene since 1954, when the plant was put into operation in Longview as a 20-million pound per year unit.

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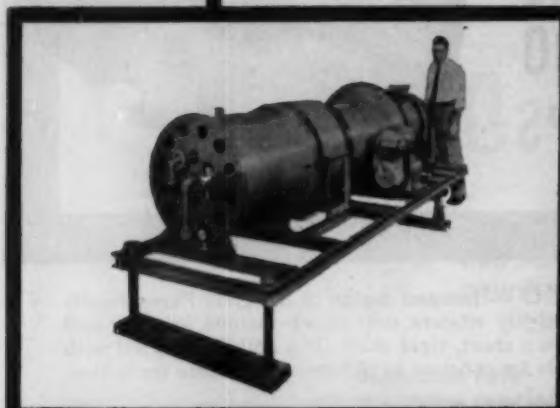
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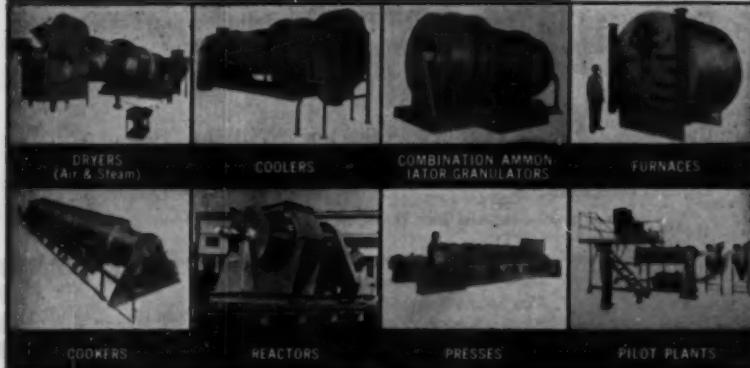
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institutional news

International Relations -- Everyone's Job

HAROLD C. RIES
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Good international relations may become of immediate personal concern to any chemical engineer at any moment in these days of "building everywhere." Hal Ries, A.I.Ch.E.'s delegate to the recent First West Coast Conference of the Experiment in International Living, reports here on one program attempting to improve international understanding.

For 27 years, people have been participating in the Experiment in International Living. During that time, it is estimated that some 70,000 people have been influenced directly through contact with the experiment.

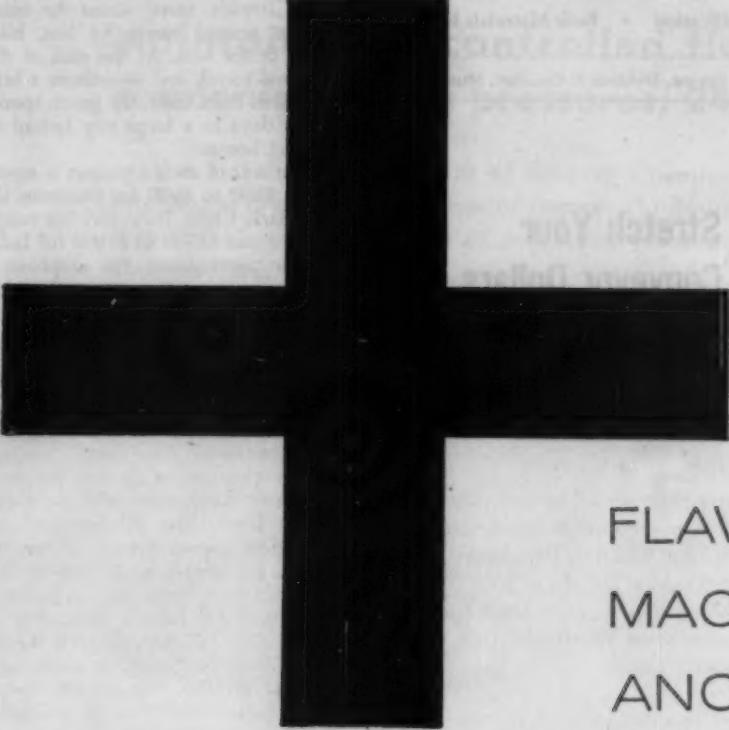
At the recent First West Coast Conference of the Experiment at San Francisco, directors, participants and delegates from many organizations, including the AICHE, met to exchange ideas on the program. The point stressed most was the need to broaden the scope of the project. Currently, some 2300 people from 25 countries participate in one year.

What it is

The Experiment is a non-profit, educational organization (with no political or religious affiliations) designed to create better understanding among peoples of the world by giving them the chance to develop personal friendships.

Persons interested in learning how other people live are selected from applicants on the basis of their interest in people, adaptability to other ways of life, language abilities, maturity, and professional competence. Age limits vary from 18 to 60, though the majority of participants are between 21 and 30. A group from the United States, usually ten with one group leader, travels together by low-cost transportation to their Experiment country. The group goes to a community where each person lives with a family for a month as a member of the family; often the host family has one member the same age as the participant. After a month of learning

continued on page 102



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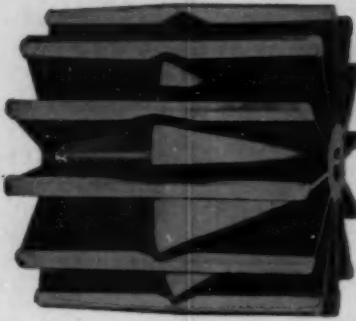
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July 1959 101



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Bore Length	Extra long to reduce shaft stress— $3\frac{1}{2}$ " bore length for $2\frac{1}{2}$ " shaft	Short bore— 2 " bore length for $2\frac{1}{2}$ " shaft
Ribs	Fewer ribs needed because belt contact area is greater	Extra ribs required, this means less space for large pieces to discharge. Greater possibility of damage

The above chart was made after careful examination of a widely advertised line of fabricated steel wing pulleys. All the points enumerated may not be true for every competitive pulley, but they are certainly worth your careful review.

COP/101

International

from page 100

about family and community life, the group, joined by some of their new-found friends, travel about the country for several weeks by bus, bike, train, or on foot. At the end of this informal travel, and sometimes a brief visit with their hosts, the group spends a few days in a large city before returning home.

The cost of such a project is mostly about \$800 to \$900 for countries like Denmark, Chile, Italy, etc. but ranges up to about \$1500 to \$1800 for India. As for participants, the emphasis is shifting more and more to the older person, especially teachers and professional people. Last year, for example, 76% of the participants were over 21 while 45% were over 25.

Another opportunity to do something is to be a host to a participant from overseas. This usually requires the cooperation of several people in the same community who are willing to be hosts. The "Community Ambassadors", another facet of the program, are people sponsored by civic and service groups in a community. In return for having their expenses paid, they are charged with the responsibility of reporting their experiences on the Experiment through local papers and through talks with local groups. On the average, each "Ambassador" gives about 40 talks after returning to the community.

You can help through the Experimental in International Living in one of three ways: (1) as a participant; (2) as a host for a participant from another country; or (3) by broadening the participation in the project by getting your community to send an "Ambassador" abroad (or perhaps by sponsoring somebody from another country to come to your community). For information on any phase of the project, write to: The Experiment in International Living, Putney, Vermont.

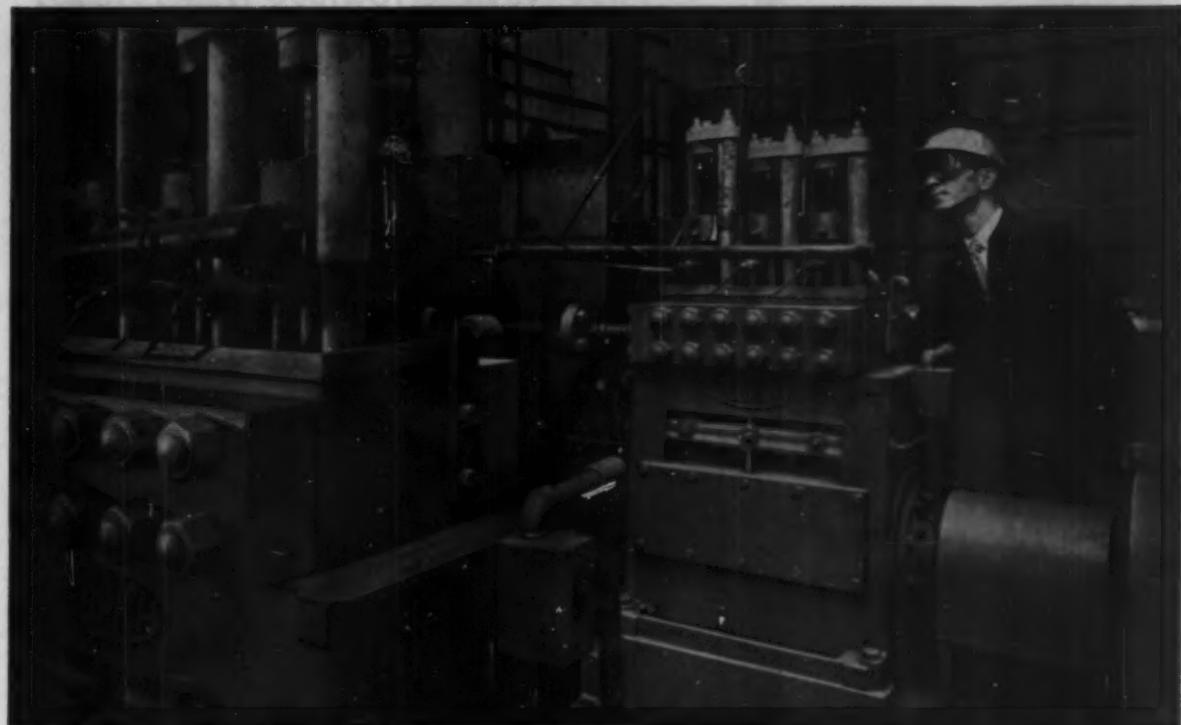
A major expansion of refractory magnesia operations takes place at Kaiser Aluminum and Chemical, when construction begins shortly on an estimated \$3 million plant at Midland, Michigan. The new unit's planned capacity is 45,000 tons a year of periclaste, which brings company production of magnesia furnace grains to 165,000. Plans call for the facilities to be supplied with magnesium hydroxide by the Dow headquarters plant at Midland. Production is scheduled to begin early in 1960.

For more information, turn to Data Service card, circle No. 35

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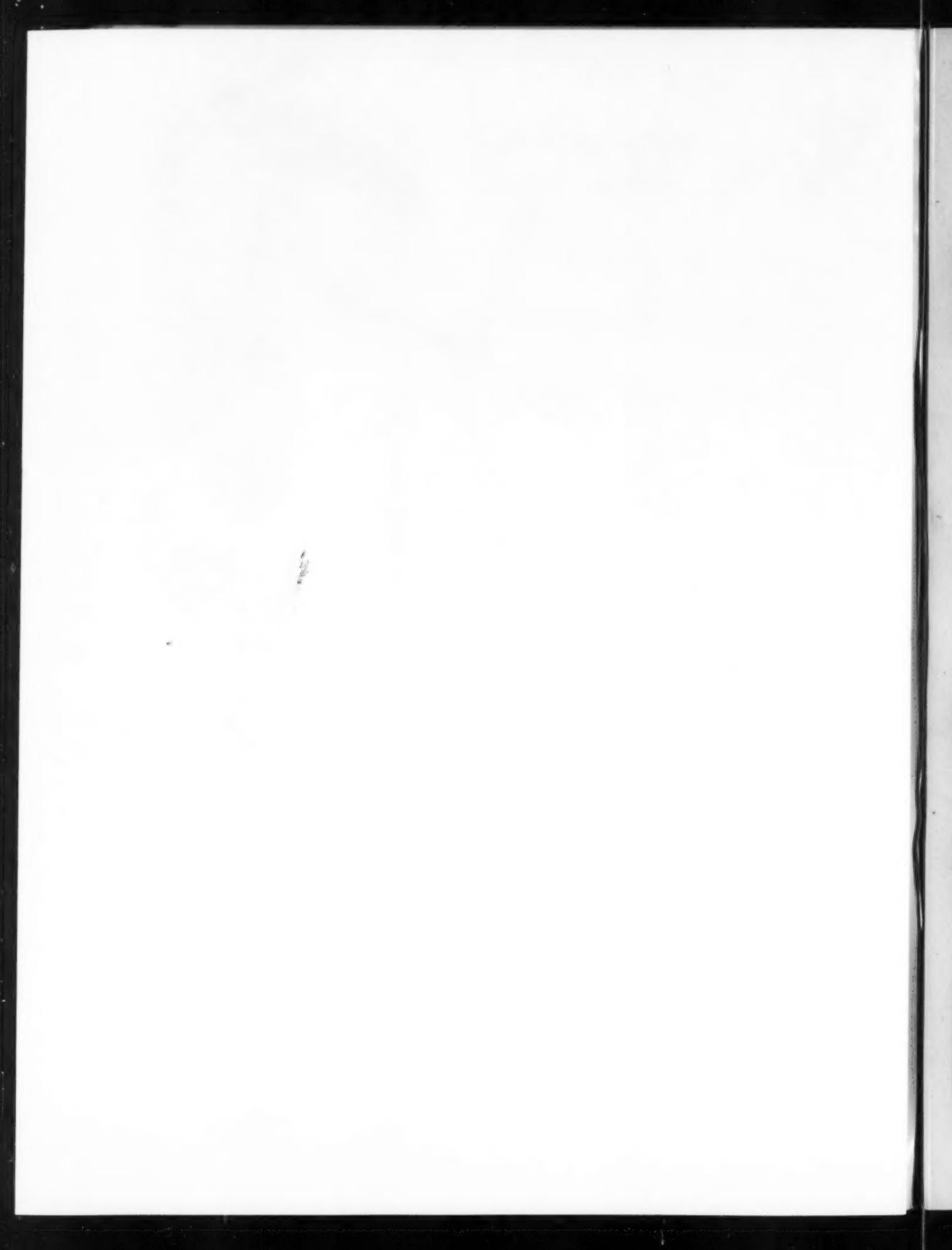
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CITY _____ ZONE _____ STATE _____

For more information, turn to Data Service card, circle No. 61

The following 4 Pages that appear to
be missing are reader service cards
and have been removed.



Spray drying NEWS



RECOGNIZED
LEADER
IN SPRAY
DRYING
SINCE 1926

VOLUME 1, NO. 1

SPEAKING FOR BOWEN

JOE QUINN,
Bowen Sales Manager,
discusses a few of the
reasons behind the
ever-increasing popularity
of spray drying.

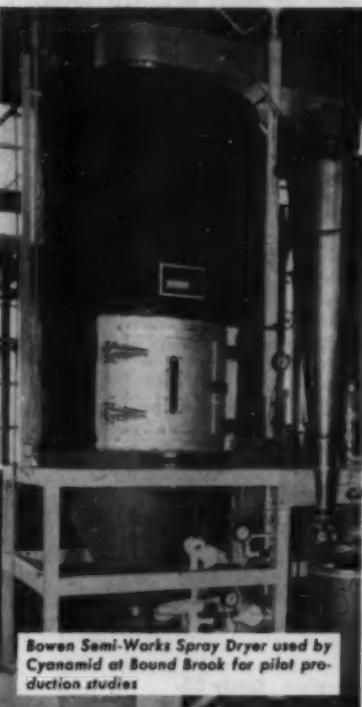
Why Spray Dry?

With 39 different types of dryers on the market, it's a safe bet that many are overlooked in selecting a dryer for a given process. Yet, a recent survey revealed that 85% of all engineers investigate spray drying when confronted with a drying problem involving a fluid material. There are compelling reasons:

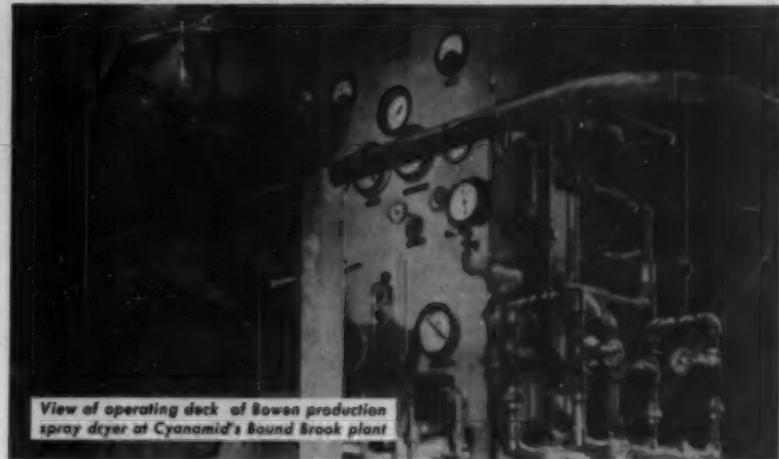
Spray drying is an extremely rapid, one-step, continuous process. Almost instantaneous conversion from liquid or slurry to dry, free-flowing solids may eliminate crystallization, filtration, grinding, screening and other costly process steps. Operating and maintenance costs are often reduced substantially.

Design and operating flexibility enables wide control of product physical characteristics. Short exposure time—a matter of seconds—makes spray drying well suited for heat-sensitive materials. And products having volatile constituents or low softening points may be further protected by patented Bowen shock-cooling techniques.

For more information, write for Bulletin #35.



Bowen Semi-Works Spray Dryer used by Cyanamid at Bound Brook for pilot production studies



Cyanamid makes "across the board" use of modern spray drying techniques

USES BOWEN PRODUCTION, SEMI-WORKS AND LAB UNITS TO IMPROVE PRODUCT QUALITY, UNCOVER NEW OPERATING ECONOMIES

Nobody has to sell American Cyanamid on the benefits of spray drying at its giant Bound Brook, N. J. facilities.

About six years ago—following promising exploratory test work at the Bowen Test Laboratory—Cyanamid's Bound Brook plant installed a Bowen Laboratory Spray Dryer. Designed to conveniently process small batches of materials, this unit enabled Cyanamid to test dry at will numerous chemical materials used in the manufacture of such diversified end products as dyes, pigments, plastics, textile resins, rubber chemicals, pharmaceuticals and other organic and inorganic compounds.

CONTINUOUS BELT DRYER REPLACED—One outgrowth of this evaluation work was a decision to replace a continuous belt dryer in the Organic Chemicals Division with a production spray dryer. Bowen and Cyanamid engineers then carried out special tests at the Bowen Laboratory to determine essential production-unit design data. Tests indicated that a 14-foot diameter drying chamber of conical design was required and Bowen proceeded with detailed spray dryer design and fabrication.

LABOR COSTS CUT—Installed in 1956, this production spray dryer operates around the clock, seven days a week—without problems—handling 45-50% filtered slurry that is fed into the drying chamber where a Bowen atomizer wheel (operated by a rugged, high-speed Bowen Spray Machine) produces the fog-like mist required for the almost instantaneous drying that typifies the spray drying process.

Production spray drying benefits at Bound Brook proved to be eye-opening. Labor costs were cut 1/2. Product yield and product quality were improved. Maintenance costs were slashed.

SEMI-WORKS UNIT FILLS GAP—The success of this production operation led management to purchase a Bowen Semi-Works Spray Dryer (4½-foot diameter drying chamber) for product development and more extensive spray drying evaluation. Filling the gap between a lab unit and production spray dryer in size, this unit permits the study of spray drying under pilot plant manufacturing conditions. It enables continuous production of hundreds of pounds of product as opposed to only a few pounds per batch with the much smaller laboratory dryer.

For more information, write for Editorial Reprint CY.

For more information, check below:

- Editorial Reprint CY
- Bulletin #35
- Bowen Test Laboratory Booklet

Information on the feasibility of spray drying:

Clip and mail with your name, title and company address to:

BOWEN ENGINEERING, INC.

North Branch 13, N. J.

For more information, turn to Data Service card, circle No. 56

CEP's DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

Equipment *from page 108*

Pumps, variable volume (p. 134). Data from Keystone Engineering on the Kemion pump, made of Teflon. Capacities to 10 gal./min. Pressures to 3,000 lb./sq. in. Circle 57.

Pumps & Valves, titanium (p. 19-20). Technical Data from U.S. Industrial Chemicals. Circle 99-1.

Rotameters, armored (p. 143). For hazardous fluids, high-pressure fluids, steam. Bulletin 19A from Schutte and Koerting. Circle 47.

Scrubbers, fume, jet-Venturi (p. 117). Complete catalog from Croll-Reynolds. Circle 79.

Separators, entrainment (p. 4). Improve performance of vacuum towers, distillation equipment, absorbers, evaporators, scrubbers. Data from Otto H. York. Circle 110.

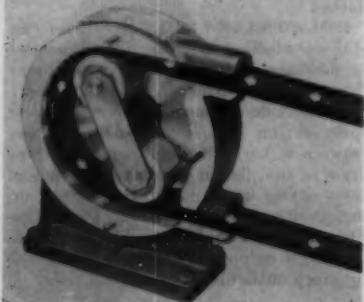
Separators, entrainment (p. 21). Designs for any capacity or special requirement. Data from Peerless Mfg. Circle 49.

Strainers (p. 148). New design strainer available in 2, 2½, 3, 4, and 6 in. sizes. Data from Schutte and Koerting. Circle 42.

Tanks (p. 143). New 16-page Catalog from Littleford Bros describes tanks of all types, shapes, and sizes. Circle 65.

Thermocouple Wells (p. 144). Bulletin 2000 from Claud S. Gordon gives specifications, sizes, ordering info on "Serv-Rite" drilled wells. Circle 11.

DEVELOPMENT OF THE MONTH



CORROSION RESISTANT PUMP (Circle 601 on Data Post Card)

A new pump designed by Randolph Co. operates on a principle which eliminates all contact of moving parts with the material being pumped. A flexible tube passes through the pump body where it is subjected to the "squeezing" action of a double rotor. The unit is said to be ideally suited to situations where the handling of corrosives, abrasive slurries, sterile solutions, or gases, is a problem.

The pump is offered in two models—54 and 185 gal./hour. It is available with or without motor; also with speed controls and explosion-proof fittings, if desired. For more information, Circle 601 on Data Post Card.

Valves, butterfly (p. 9). Any size, any metal or alloy, any temperature, any pressure, any fluid. Data from Fisher Governor. Circle 18.

Valves, gate, bronze (p. 22-23). Circular from Wm. Powell Co. describes new design bronze union bonnet gate valves for 125 and 150 pounds WSP. Circle 25.

Vessels, storage & transport (p. 95). Data from Hofman Laboratories on vessels designed for low-temperature storage of liquid oxygen, nitrogen, hydrogen, helium. Circle 105.

Viscometer (p. 124). Catalog from Brookfield Engineering Laboratories on new 8-speed "Synchro-Lectric" viscometer. Circle 36.

DEVELOPMENT OF THE MONTH



TURBINE AGITATORS

(Circle 605 on Data Post Card).

A new line of turbine agitators, developed by Chemineer, Inc., can meet a wide variety of process requirements from inventoried modular components. Five basic gear-drive configurations are available in sizes through 75 hp: right angle head, belt driven, in-line with coupled motor, in-line with integral motor, and variable speed. Each configuration is built in seven basic case sizes, with a choice of any AGMA gear ratio, and a choice of three mountings for open and closed tanks.

Lubrication of all moving parts in the gear case is provided by a positive oil pump. A dry-well seal prevents leakage. In addition to choice of material for wetted parts, three standard impeller styles are offered: straight blade, curved blade, and 45 degree pitched blade. For complete technical details, Circle 605 on Data Post Card.

DEVELOPMENT OF THE MONTH



TUNGSTEN CARBIDE-LINED GRINDING MILLS

(Circle 603 on Data Post Card).

The "Micronizer" fluid energy grinding mill made by Sturtevant Mill, is now on the market with tungsten carbide linings for the fine grinding of severely abrasive materials up to the hardness of tungsten carbide.

Three sizes of the tungsten carbide-lined mills will be offered—from 4 to 15 in. diameter. For full technical details, Circle 603 on Data Post Card.

Materials *from page 105*

Solvents (p. 125). "Solvent Selector" from Union Carbide Chemicals lists 69 solvents, couplers, and diluents, plasticizers. Gives evaporation rates, viscosities, flash points. Circle 70.

Solvent (p. 149). Loosens stuck-together metal parts, bushings, bearings, bolts, screws, pipe. Data from Kano Labs on "Aerokroll." Circle 50.

Synthetic Rubber (p. 121). Complete technical data from Dupont on Viton synthetic rubber as material for O-rings, gaskets, hose, tubing, other resilient parts. Circle 28.

Wire Cloth (p. 12). In all corrosion-resistant metals, in wide range of meshes. Data from Newark Wire Cloth. Circle 23.

Services *from page 105*

Fabrication, processing equipment (p. 144). Data on facilities available at International Process Equipment Co. Circle 75.

Fabrication, steel plate (p. 149). Data from Posey Iron Works on facilities for fabrication of towers, storage tanks, pressure vessels. Circle 51.

Nuclear Papers (p. 141). Data from United Nations on English edition of Proceedings of 2nd Geneva Nuclear Conference. Circle 53.



News from National Carbon Company

Division of Union Carbide Corporation • 30 East 42nd Street, New York 17, N.Y.
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York,
Pittsburgh, San Francisco. IN CANADA: Union Carbide Canada Limited, Toronto

Marketing Manager, Chemical Products



W. W. PALMQUIST

Mr. Palmquist was graduated from Yale University with a B.S. in Chemical Engineering. He has spent ten years preparing design proposals, developing new designs and improving existing designs of "Karbate" chemical processing equipment. Based on this extensive design and development background, Bill was made Manager of Sales Promotion and Development for the Chemical Products Sales Department.

For the past year, Bill has been Chemical Products Marketing Manager and is responsible for marketing the complete line of "National" carbon and graphite products and "Karbate" impervious graphite for the chemical processing and allied industries.

He is a member of the American Institute of Chemical Engineers, the National Association of Corrosion Engineers and the Electrochemical Society.

NATIONAL CARBON FABRICATES 20-FT. LONG "KARBATE" TUBE HEAT EXCHANGER

National Carbon Company was requested to replace a steel bundle in an existing all steel shell and tube heat exchanger. This presented a problem of 20-foot long tubes plus a two pass shell side arrangement. Photograph below illustrates the design of the "Karbate" baffle system used to reproduce the two pass shell feature. The 20 foot "Karbate" tube bundle was installed in the customer's existing steel shell and is now in service.



For more information, turn to Data Service card, circle No. 76

CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

"KARBATE" CONDENSERS PROVIDE LONG, ECONOMIC LIFE IN CORROSIVE SERVICES



A bank of 4 "Karbate" condensers in an organic chemical plant.

10 to 15 Years of Trouble-Free Service

Eleven shell and tube heat exchangers have proved the excellent corrosion resistance of "Karbate" impervious graphite material. These exchangers have provided ten to fifteen years of trouble-free operation in condensing a highly corrosive

chlorinated hydrocarbon.

Based on this performance record, additional "Karbate" shell and tube heat exchangers are planned for expansion and renovation programs in this plant.

"KARBATE" Condenser replaces Silver Condenser

To overcome the silver condenser problems of high-cost, specialized fabrication and exacting maintenance procedures, a "Karbate" shell and tube condenser was installed by a major chemical company in an *acetic anhydride* condensing application.

The unit is handling 80% *acetic anhydride* vapor at a temperature of 100°C.

The replacement "Karbate" impervious graphite unit has provided excellent heat transfer and examination after 20 months of service show it to be as good as new.



The terms "National", "Karbate", "N" and Shield Device and "Union Carbide" are registered trade marks of Union Carbide Corporation.



CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT

301 Autoclave, bench-scale. Pressure Products Industries announces new autoclave specially-designed for bench-scale research. Pressures to 5,000 lb./sq. in. Technical data.

302 Catalytic Oxidation Systems. Bulletin from Oxy-Catalyst describes use of catalytic oxidation systems for air pollution control and process heat recovery.

303 Centrifuge, continuous. In special steel, particularly suitable for separation processes operating around minus 30°F. Details from Baker Perkins.

304 Compressors, air-cooled. New 16-page Bulletin from Joy Manufacturing gives specifications on 8 sizes in the 15 to 125 hp, 81 to 641 cu. ft./min. range.

305 Compressors, heavy-duty. Bulletin from Pennsylvania Pump and Compressor on horizontal, heavy-duty, class 3-ATC compressors. Complete construction details.

306 Computer, control, digital. Bulletin from Thompson-Ramo-Wooldridge gives details of the RW-300 digital control computer for automatic control of continuous and batch processes.

307 Computer, digital, general purpose. Bulletin from Bendix gives basic computation times, memory, number system, word size, reliability.

308 Computers, nuclear applications. New 8-page Brochure "Nuclear Reactor Monitoring," from Thompson-Ramo-Wooldridge describes use of the RW-300 Digital Control Computer in nuclear reactor in France.

309 Computers, transistorized. Bulletin from Datamatic Div., Minneapolis-Honeywell describes speeds, capacities, performance qualifications of the Honeywell 800 system.

310 Couplings, flexible. Brochure from T. B. Wood's Sons on design and applications of "Sure-Flex" flexible couplings.

311 Cryogenerators. Bulletin from North American Phillips describes construction details, gives detailed list of processing applications.

312 Cryogenic Systems. Brochure from Air Products describes theory and practice of cryogenics, available equipment, custom facilities.

314 Dryers, spray. Bulletin from Proctor & Schwartz describes industrial-scale custom-built models, also pilot-plant and semi-works types.

315 Equipment, processing, graphite. Bulletin from Falls Industries gives cost estimation data on all types of standard impervious graphite processing equipment.

continued on page 114

MATERIALS

354 Amines, alkyl and alkyliene. New 52-page Booklet from Union Carbide Chemicals gives data for 19 alkyl and alkyliene amines, including physical properties, tables and charts, shipping data, constant boiling mixtures, specifications.

355 Boron Compounds. Bulletin from Calvary Chemical lists physical properties of 17 chemicals common to boron chemistry and related fields.

356 Caprolactam. Revised Technical Bulletin from National Aniline Div., Allied Chemical, gives physical and chemical properties, chemical reaction routes to commercial products.

357 Catalyst, hydrogenation. New Information Bulletin from Girdler Catalysts on G-43 platinum-base hydrogenation catalyst. Operating and physical characteristics, catalyst life, payout periods in typical applications.

358 Coatings, corrosion-proof. General Catalog CC-3 from Atlas Mineral Products describes corrosion-proof rigid plastic fabrications, cements, coatings, linings.

359 Filter medium, anthracite. Brochure from Palmer Filter Equipment describes properties, applications of "Anthrafilt," hard coal filter medium.

360 Heat Transfer Medium. Bulletin from Du Pont on properties and applications of "Hitec" heat transfer salt which allows operation at atmospheric pressure at temperatures from 300 to 1,000°F.

361 Lithium. Technical Data Bulletin 101 from Foote Mineral gives physical, chemical, thermodynamic properties of lithium metal. Extensive bibliography.

362 Mastics. Bulletin from Benjamin Foster describes applications of corrosion-resistant and insulating mastics.

363 Metal Acetylacetones. Physical properties and potential uses described in Folder from Union Carbide Metals. Extensive bibliography.

364 Neopentyl Glycol Polyesters. Technical Data Report gives data on catalytic reaction of neopentyl glycol with dibasic acids to form hydroxy-terminated polyesters. Eastman Chemical Products.

365 Octylene Oxide. Technical Information Sheet 71 from Chemicals & Plastics Div., Food Machinery and Chemical, gives formulations for a casting resin-amine cure, and for casting resin-acid cures.

366 Packings, hydraulic. New 16-page Brochure on homogeneous and fabric-reinforced hydraulic packings offered by Crane Packing.

continued on page 114

SERVICES

372 Design and Construction, ammonia plants. New Booklet from Girdler Construction Div., Chemetron, gives process data, flow sheet.

373 Design and Construction, nitration process plants. Info on nitration, other chemical processes owned and developed by Meissner (Germany) given in Brochure from Girdler.

374 Design and Construction, plants. New 24-page Brochure from Foster Wheeler titled "The Plant You Want to Build" details worldwide process engineering services.

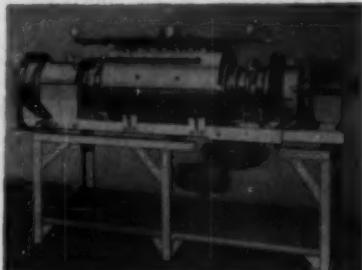
375 Fabrication, distillation equipment. Brochure from Vulcan Mfg. discusses tower sizing and design factors for packed towers, bubble cap towers, other distillation equipment.

376 Fabrication, heating equipment. Data from Posey Iron Works on facilities for fabrication of all types of rotary kilns, calciners, dryers, roasters, ovens, furnaces.

377 Fabrication, plastic processing equipment. Bulletin from Haveg describes new design service for heat exchangers, falling film absorbers, towers, chlorine coolers.

378 Fabrication, processing equipment. Bulletin from Bethlehem Foundry & Machine describes facilities for fabrication of equipment for reaction, heat transfer, mixing, drying.

DEVELOPMENT OF THE MONTH



EXPERIMENTAL SIZE CALCINER (Circle 606 on Data Post Card)

A new research-size continuous rotary combination calciner and cooler, built by C. O. Bartlett & Snow, is said to be ideally suited for continuous heating and subsequent cooling of metal oxides, chemical salts, hematite and other ores, carbonaceous and other materials, in a neutral, oxidizing or reducing atmosphere. Material can be heated to a maximum of about 2,000°F and cooled to the range of 150-200°F before discharge.

These units are available in two sizes. Both types can be either fuel-fired or electrically heated. For complete details, including data sheets, and dimensional and sectional drawings, Circle 606 on Data Post Card.



ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue

New York 17, N. Y.

ETHYLENE OXIDE-GLYCOL PLANT ON STREAM FOR CALCASIEU CHEMICAL CORPORATION

**Lummus Designs and Engineers Plant to produce
60,000,000 Lbs./Year of Ethylene Oxide or
8,000,000 Gallons/Year of Ethylene Glycol**

Calcasieu Chemical Corporation's new ethylene oxide-glycol plant at Lake Charles, Louisiana is on stream and producing 8,000,000 gallons annually of ethylene glycol, used principally as a permanent anti-freeze, or 60,000,000 lbs./year of ethylene oxide.

Designed and engineered by The Lummus Company, the plant utilizes the Shell Development Company process. The facility is staffed and operated by employees of Petroleum Chemicals, Inc. P.C.I. will also supply ethylene raw material to the new plant from an adjacent ethylene unit which

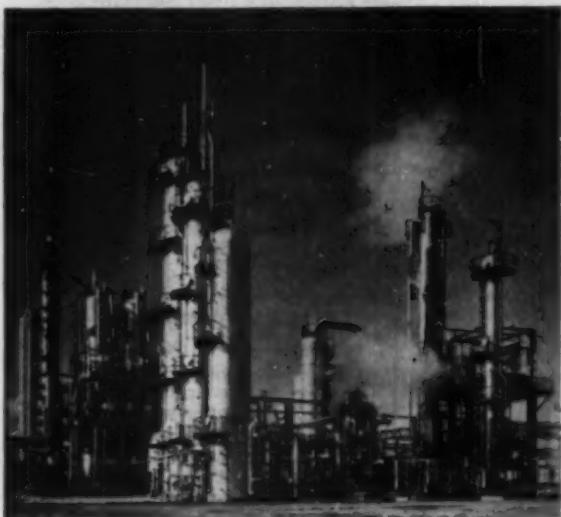
was also designed, engineered and constructed by The Lummus Company.

The Shell Process, which offers the advantages of unusually high yields and virtual elimination of the waste disposal problems encountered in the Chlorhydrin Process, is conducted in two steps. The first step is direct catalytic oxidation of ethylene with oxygen in fixed bed reactors. Here ethylene oxide, valuable petrochemical intermediate, is produced for use by manufacturers of detergents and other surface active agents, plasticizers, solvents, textiles, drugs and many other petrochemical compounds.

The second step of the Shell Process calls for thermal hydration of ethylene oxide to ethylene glycol, essential to manufacturers of anti-freeze, explosives, plasticizers, fibers, resins, hydraulic fluids and many more chemical products.

This is the third ethylene oxide unit engineered and constructed by Lummus, based upon the Shell Process. For ethylene oxide and ethylene glycol, or for any type of chemical or petrochemical plant, Lummus' half century of world-wide experience on more than 800 plants for the process industries is at your disposal.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y., Houston, Washington, D. C., Montreal, London, Paris, The Hague, Maracaibo. *Engineering Development Center: Newark, N. J.*



For more information, turn to Data Service card, circle No. 20

CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959 113

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

Equipment from page 112

316 Equipment, reinforced plastic. Bulletin P-11 from Havsg Industries describes wide application range of polyester glass corrosion-resistant industrial equipment.

317 Feeders, chemical, low-capacity. Data Sheet from B-I-F Industries gives construction details, line drawings, specifications.

318 Fittings and Flanges. New 12-page Booklet FB-78 is guide to material selection of carbon, alloy, and stainless steel welding fittings and flanges. Babcock & Wilcox.

319 Flowmeters, turbine-type. For pressures from 0 to 35,000 lb./sq. in., temperatures from minus 455 to plus 1,500°F. Linear range of 10 to 1 or better. Details from Potter-Bowser Meter Div., Bowser, Inc. Bulletin.

320 Gauges, test. Catalog 400 from United States Gauge gives selection data, specifications, ordering info.

321 Grinding Mills. Catalog 63 from Bradley Pulverizer gives details of semi-fine and fine screen and pneumatic roller mills. Complete specifications, weights.

322 Heat Exchangers. Catalog on "Design and Cost Comparison of Heat Exchangers using Wolverine Trufin," offered by Wolverine Tube (Calumet & Hecia).

323 Heat Exchangers, panel-coil. Price Data Bulletin 259 from Dean Products gives specifications and prices on complete line of "Thermo-Panel" coils.

324 Indicators, specific gravity. For continuous measurement of liquid specific gravity. Complete construction details, dimensional and cross-sectional drawings. Bulletin 185 from Schutte and Koerting.

325 Mixers, horizontal. In carbon or stainless steel, other alloys, with various arrangements of ends, discharges, agitators, drives. Bulletin F-1058 from Young Machinery.

326 Mixers, rotary batch, small. Data Sheet from Munson Mill Machinery describes the "Mina-Mixer," for pilot plant operation, small production runs.

327 Nozzle Liners, Teflon. For use in nozzle openings of reactors, vessels, condensers, pumps, heat exchangers. Inert to acid, industrial chemicals at temperatures to 500°F. Data from ResistoFlex.

328 Packers, vibratory. Syntron offers new Catalog Section on pulsating-magnet vibratory packers and hydraulic jolters. Complete descriptions, data, specifications.

329 Packing, tower, ceramic. Improved resistance to hot, strongly alkaline solutions is claimed for new ceramic tower packing composition made by U. S. Stoneware. Available in Raschig rings in diameters from $\frac{1}{4}$ to 4 in. Technical info.

330 Piping, ductile iron. Bulletin from James B. Clow & Sons describes chemical processing advantages of ductile iron pipe. Physical properties, corrosion-resistance data, specifications, dimensions, weights.

331 Pulverizers. Technical Bulletin 093 from Sturtevant Mill gives details of new "Pulver-Mill," a vertical impact mill with an integral air classifier. Can handle up to $2\frac{1}{2}$ tons/hr. of soft, non-metallic materials.

332 Pulverizers, jet. New Brochure from Jet Pulverizer Co. describes applications in dry pulverizing of materials to micron-size powders. Units available in 8 sizes, mill diameters from 2 to 36 in.

333 Pumps, canned. Technical Bulletin 2 from Chempump describes advantages of canned pumps in handling ethylene and propylene chemicals, and their intermediates.

334 Pumps, centrifugal. Bulletin 104A from Frederick Iron & Steel on double-suction, single-stage centrifugal pumps. Performance data and structural details.

335 Pumps, low-volume. Bulletin 856-2 from Orchem Pumps describes the "Little Giant" pump for all low-volume, medium pressure, chemical metering applications.

336 Pumps, proportioning, chemical. New Model 1210 "Chem-O-Feeder," made by B-I-F-Industries, features corrosion-resistant transparent plastic head, Hypalon diaphragm and check valves. Technical data.

337 Pumps, rotary, internal gear. Three Bulletins from Wayne Pump contain performance data, specifications of its Series B, C, and D internal gear rotary pumps.

338 Pumps, sump, vertical, rubber-lined. Available in capacities from 20 to 1,400 gal./min., sizes from 2 by 2 in. to 6 by 6 in. Bulletins P9V-B1 and P9V-B2 from Denver Equipment.

339 Recorder, initial boiling point. For continuous determination of initial boiling points of light hydrocarbons between 200 and 400°F. Data Sheet from Hallikainen Instruments.

340 Regulators, pressure, pneumatic. Bulletin from Marotta Valve gives specifications, pressure and electrical characteristics of automatically-operated, remotely-controlled pneumatic pressure regulators.

341 Scrubbers. New, 8-page Bulletin 803 from V. D. Anderson is a complete catalog of purifiers, separators, mist extractors, scrubbers.

344 Television, industrial. Bulletin from Philco gives specifications, dimensions, accessories, describes applications to process control.

345 Transmitters, pressure. New Specification Sheet 10B1460 from Fischer & Porter gives full technical data on low flow-rate differential pressure transmitters for liquid or gases.

346 Tubing, nickel. Folder from Superior Tube lists chemical composition, physical constants, mechanical properties of 4 types of nickel tubing.

347 Tubular Products. Bulletin 12 from J. Bishop gives specifications of stainless tubing, nickel & nickel alloy tubing, special metals and alloys, fabricated parts, specialties.

348 Valves, control. Bulletin LB-3 from Conoflow gives construction details, specifications, details of integrated body-actuator design.

353 Water Treating Equipment. New 24-page Booklet from Elgin Softener describes manual and automatic zeolite water softeners, demineralizers and deionizers, dealkalizers, ion exchangers, filters, purifiers, aerators, and degasifiers.

Materials from page 112

367 Packings, mechanical. New 56-page Catalog from Flexrock shows specifications of complete line of metallic and non-metallic packings and accessories.

368 Radiochemicals. Catalog and Price List from New England Nuclear lists carbon-14 and tritium labeled compounds, radioassay services, standard reference sources and compounds.

369 Refractories. Bulletin RB-20 from Richard C. Remmey Son Co. lists many types of refractory brick, cements, catalyst carriers, heat exchange pebbles.

370 Synthetic Rubber. A 16-page Data and Specification Book on Ameripol Micro-Black masterbatch synthetic rubbers is offered by Goodrich-Gulf Chemicals. Complete specifications on 7 types of the material.

371 Yttrium. New Data Sheet from Nuclear Corp. of America on yttrium metal gives thermal properties, crystal structure, electrical properties, corrosion data.

A.I.Ch.E. Membership

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 604 on Data Post Card.

the **BEST PUMP**

for volatile fluids is the Canned Pump

Pump and motor are a single, leakproof unit . . .
with no seals or stuffing boxes. Volatile fluids
stay inside where they belong.

CHEMPUMP

is the Canned Pump

. . . the answer to your difficult pumping problem.
Only Chempump—the original canned pump—offers you
these advantages:

- **experience-proved design . . .**
stemming from 7 years of rugged field
service. *Only Chempump has it!*
- **nation wide field engineering . . .**
personnel with specialized application
knowledge you must have. *Only Chempump has it!*
- **field-proven performance record . . .**
in thousands of installations in all types of
service. *Only Chempump has it!*

Use *the* canned pump—Chempump—to handle your
volatile or toxic or costly, or any other "problem" fluid.
Write today . . . for "request for quote" data sheet . . .
to Chempump Corporation, Buck and
County Line Roads, Huntingdon Valley, Pa.



Chempump

First in the field...process proved

For more information, turn to Data Service card, circle No. 78

Molecular sieve route to octane improvement

New Linde-developed process claimed to offer technical and operating advantages, significant reduction in investment and production costs.

Hot off the development griddle is a new process for octane improvement which is presently being offered by Linde to major petroleum refiners. Details of the process are being made available without charge—Linde's interest lies only, says the company, in the sale of the molecular sieves which are the key to the method.

The Linde molecular sieve Type 5A is highly selective for normal paraffins in the presence of branched-chain and cyclic hydrocarbons. The crystal will accept and adsorb only those molecules having a critical dimension less than about 5 angstrom units. Isoparaffins and cyclic hydrocarbons are therefore excluded by their physical size.

Range of possible applications

The role of molecular sieves in octane improvement processes is the separation of normal paraffins from isomeric and cyclic hydrocarbons. They can therefore be applied to separation steps in such processes as isomerization, reforming, or alkylation. With isomerization, for example

	MOLECULAR SIEVE SEPARATION	FRACTIONATION
FEED		
Charge rate, BPSD	4,000	4,000
Octane number, F-1 + 3 cc TEL	88.5	88.5
Unit value, \$/bbl.	4.74	4.74
Daily cost, \$/SD	18,940	18,940
ISOMER PRODUCT		
Quantity, BPSD	3,959	3,953
Octane number, F-1 + 3 cc TEL	99.5	97.6
Unit value, \$/bbl.	6.17	5.73
Daily realization, \$/SD	24,400	22,670
PROFIT MARGIN		
Product realization, \$/CD	21,960	20,403
Feed cost, \$/CD	17,050	17,050
Difference, \$/CD	4,910	3,353
Fuel gas credit, \$/CD	52	52
Total, \$/CD	4,962	3,405
Operating cost, \$/CD	2,672	3,340
Profit margin, \$/CD	2,290	65
Tax, @ 52%, \$/CD	1,190	33
Profit margin after taxes, \$/CD	1,100	32
Depreciation, \$/CD	645	791
Cash income after taxes, \$/CD	1,745	823
PAYOUT		
Plant investment, \$	2,320,000	2,845,000
Payout time, years	3.6	9.5
RETURN ON INVESTMENT		
Initial investment, \$	2,632,800	2,920,000
Ratio of initial investment to annual cash income	4.13	13.1
Return on investment, % per year	24.2	7.6

Figure 2. Comparison of return on investment and payout, 4000 BPSD Hydro-isomerization plants. (Gulf Coast location)

the sieves can be used to remove the normal paraffins from a pentane-hexane combined feed and recycle, giving a means of isomerizing both pentane and hexane to extinction at a relatively low cost. Light reformates

can be processed in a similar manner, while the possibility of removing normal paraffins from a full range reformate is claimed to offer a process entirely impractical by fractionation techniques. Molecular sieves might also be used to advantage to separate normal butane from isobutane in such processes as isomerization and alkylation.

Several possible cycles

Desorption is usually the most inefficient step in the cycle: several variations are possible:

- Thermal swing cycles using either direct heat transfer by contacting the bed with a hot fluid, or indirect heat transfer by heating the bed through a surface such as finned tubes;

- Pressure swing cycles;

- Purge gas stripping cycles using an essentially non-adsorbed gas which is either easily condensable or generally non-condensable;

- Displacement cycles where the adsorbed phase is displaced by an adsorbable purge gas which is either

continued on page 118

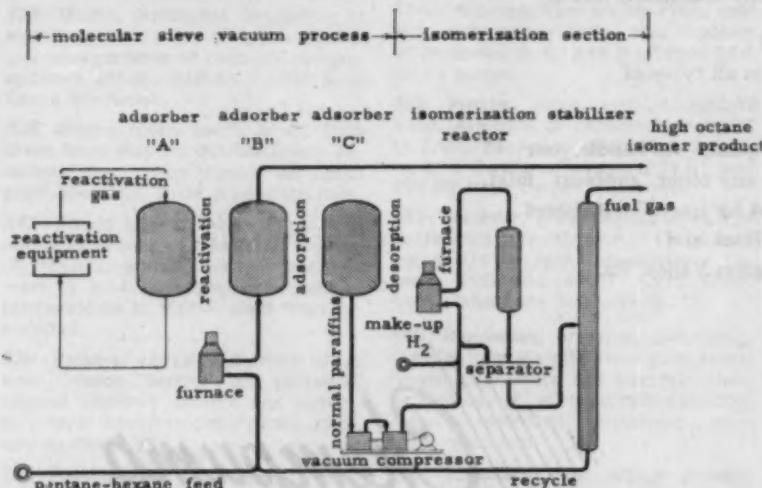
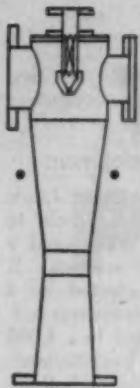


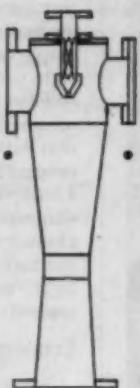
Figure 1. Simplified flow diagram of molecular sieve vacuum process with Hydroisomerization.



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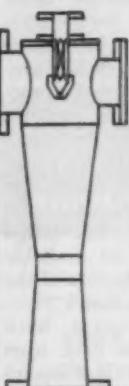


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Molecular sieve

from page 116

more strongly adsorbed, or less strongly adsorbed than the compound being desorbed.

Detailed process development

Out of all the possibilities, Linde chose one specific process cycle to develop a preliminary design and a preliminary economic analysis. A vacuum process was selected as a typical example. This process was considered to be incorporated in a 4,000 BPSD pentane-hexane hydroisomerization plant with recycle of both n-pentane and n-hexane to extinction. An alternate fractionation scheme was also developed to provide an approximate yardstick for the economic evaluation. Foster Wheeler Corp. was employed to provide preliminary designs for all major equipment in sufficient detail to establish feasibility of operation, and to obtain reliable cost estimates and economic data; all process design calculations were by Linde. Figure 1 is a simplified flow diagram illustrating the basic steps including isomerization of the n-paraffin product. The feedstock is a typical light naphtha containing 45 vol-% normal paraffins.

Economic comparison

Figure 2 shows a comparison of return on investment and payout on two hypothetical 4,000 BPSD hydroisomerization plants, one using the molecular sieve route, and the other based on conventional fractionation methods. Assumed plant location is the Gulf Coast. Linde officials emphasize that applications of the process to full scale production facilities will probably have to go through a pilot plant stage: the work on which the present estimates are based was carried through on a bench scale only.

Full experimental data and design procedures are said to be available to allow preliminary evaluation of the application of molecular sieve processes to octane improvement. Such data includes equilibrium data, mass transfer data, and the results of studies on the operating life of the absorbent.

A 500 ton per day sulfuric acid plant is planned at Sulphurdale, Utah, on American Sulphur's 15,000 sulphur properties. A new company, Dixon-Western Chemicals, has been jointly formed by Dixon Chemical and American Sulphur for that purpose. An over-all sulphur complex is planned, with this initial step representing an investment of over \$3 million.

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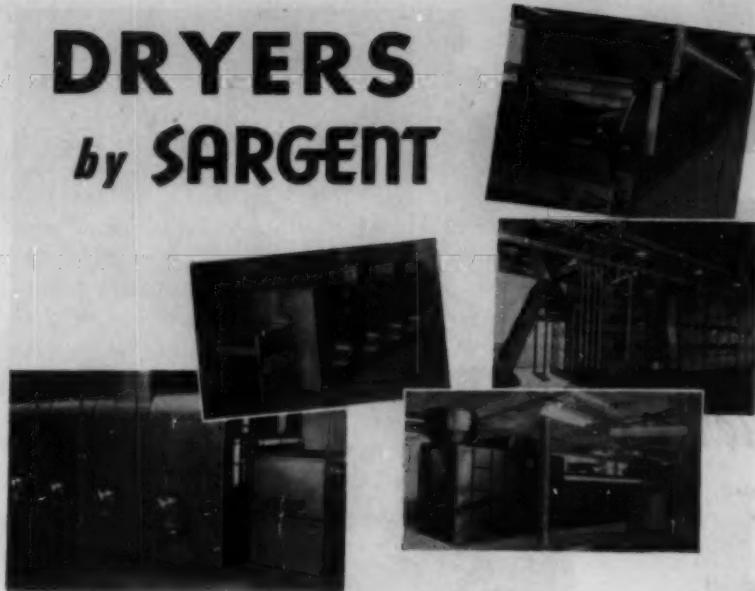
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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959 119

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institutional news

"21-and-Over Club" -New members

Results of the 1958 membership drive show that nine representatives of local sections throughout the country have qualified for membership in the "21-and-Over Club," by mustering that number of applications for new members throughout the year. The exclusive club, established by CEP in 1957, annually adds to its membership only those who bring in twenty-one or more applications during the year.

According to figures just released, the Northern Division as a whole won out over the Southern, with D. E. Abercrombie, Philadelphia-Wilmington, topping the list with 108 applications.



Northern division: (Top, l. to r.) Abercrombie, Slagie, Frank. (Bottom) Bergman, Henry.



Southern Division: (Top, l. to r.) Burkett, Morrison. (Bottom) Scott, Kunkel.

The new membership leaders are:

REPRESENTATIVE	SECTION
D. E. Abercrombie	Phila. Wilmington 108
W. J. Burkett	South Texas 75
K. H. Slagie	Pittsburgh 42
J. E. Frank	Chicago 41
H. B. Morrison	St. Louis 36
R. I. Bergman	New Jersey 34
J. Henry	New York 33
J. M. Kunkel	Southern California 33
J. W. Scott	Sabine Area 25

A consistent increase has been

continued on page 122

VITON® O-Rings seal heat exchanger at 525° F.

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Kontro Adjust-O-Film centrifugal processing units are commonly used as continuous evaporators. They operate by spinning the product in a thin film against a heat transfer surface. Heat exchange is extremely fast and hold-up very low, so high temperatures can be used.

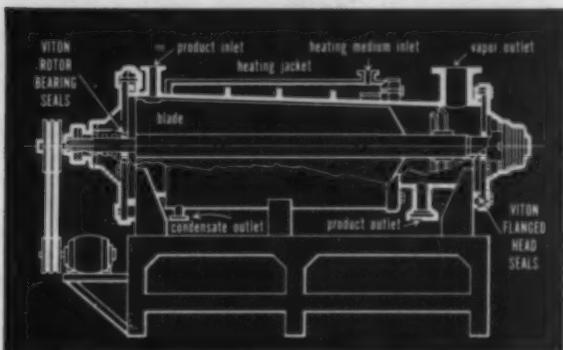
Bearing seals from pilot plant model (shown above) operated at 525° F. The one on the left was made from a standard synthetic rubber; the one on the right from VITON. Performance like this led to use of VITON on commercial models of the heat exchanger. Location of VITON seals is indicated in the diagram, right.

Expose most synthetic rubber O-ring seals to temperatures as high as 525° F. . . . subject them, at these high temperatures, to chemicals like fatty acids, dibasic acids, phthalic acid, solvents and petroleum products. Do all this, and *you know* what happens: the rubber loses its strength and resilience; it becomes useless as a sealing material. The only thing you can do is cut back your operating temperature to protect the seals.

That's exactly what The Kontro Company, Inc., had to do on one processing job for their new centrifugal heat exchanger. They had to restrict product temperature to 400° F.—125° below the 525° F. needed for optimum performance.

But that was before VITON. VITON synthetic rubber changed everything. Kontro's own tests show that VITON O-rings work just fine in intermittent operation of these heat exchangers at 525° F., lasting 12 to 25 times longer than other synthetic rubbers that have been tried.

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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

July 1959 121

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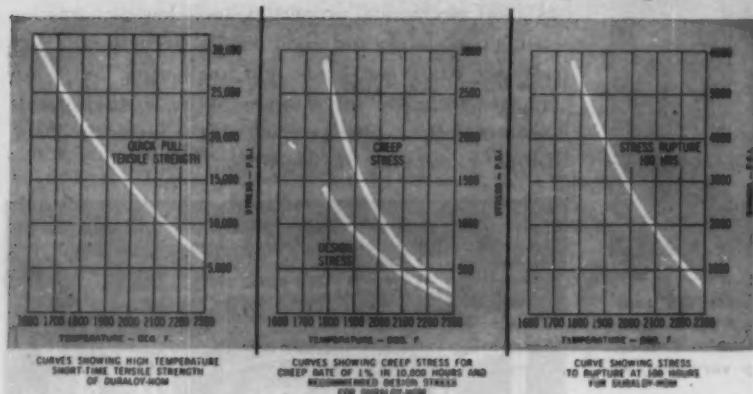
DURALOY

HOM

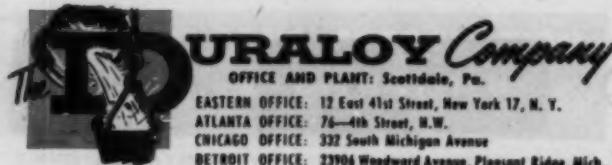
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For more information, turn to Data Service card, circle No. 16.

21-and-Over

continued from page 120

shown each year over a period of four years in the number of applications received. Total number in 1958 is 1842, as compared with 1667 in '57. (Average number actually accepted usually runs about 98 percent.)

The contribution of the men pictured here is one of the most important factors in the continuing growth of the Institute. Their dedication to the organization, and the hard work they did to spark-plug the drive for new applications, have well earned them recognition, as leaders of their sections. Their efforts will be an inspiration to the rest of us to continue to work to make the Institute grow.

Heat Transfer Preprints Available

Preprints are now available for all A.I.Ch.E.-sponsored papers to be given at the coming 3rd Annual Heat Transfer Conference to be held this summer at the University of Connecticut, Storrs, Conn., August 9-12. For details see listing of papers and order blank on page 149 this issue.

Production of synthetic resins will begin at Medellin, Colombia, under a license agreement between Probst & Cia., Ltda., and Reichhold Chemicals, in which techniques developed by RCI will be used by the W. R. Grace subsidiary. Surface coatings and adhesives industries of Colombia will be the principal consumers of these resins.

A ten million pound per year polypropylene film plant to be built near New Castle, Delaware, by AviSun, is expected to be completed this fall. A pilot plant for manufacturing polypropylene, continuous filament and staple fibers is also being erected at the New Castle location. AviSun, new equally owned affiliate of Sun Oil and American Viscose, was formed this year to manufacture, process and market polypropylene resins, films and fibers.

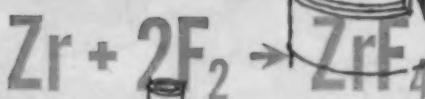
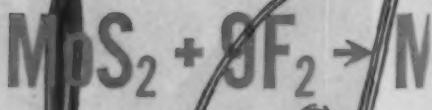
Research and development of a third-stage engine for the solid-fuel Minuteman intercontinental ballistic missile will be done by Hercules Powder, under a contract awarded them by the Air Force. Work will be carried out at the company's rocket propellant facility at Bacchus, Utah, while supporting technical work is done at Kenvil, New Jersey.

FLUORINE BOMB CALORIMETRY

Fluorine bomb calorimetry has been considered by many a thermochemist as he vainly struggled to react a stubborn compound with oxygen. However, the extreme chemical reactivity of fluorine presents difficult problems in handling and containment. Recently at Argonne, thermochemists have collaborated with scientists skilled in the techniques of fluorine chemistry to make fluorine bomb calorimetry a reality. Important thermochemical data is now being obtained on substances not amenable to conventional oxidation bomb studies. Many of the compounds which are used in high temperature chemistry because of their resistance to oxidation will be studied with this promising new thermochemical tool.

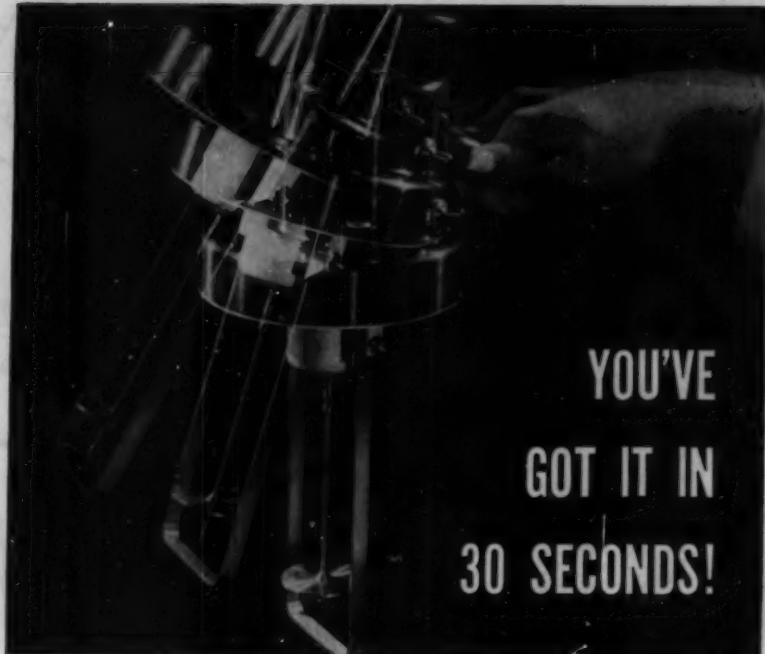
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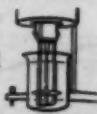


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future meetings

1959—MEETINGS—A.I.Ch.E.

• Storrs, Conn. August 9-13, 1959. Univ. of Conn. A.I.Ch.E.-A.S.M.E. Heat Transfer Conference. Pres. Chmn.: M. T. Cichelli. Eng. Research Lab., DuPont, Wilmington, Del. See June CEP, p. 138.

• Austin, Tex. Sept. 9-11, 1959. Univ. of Texas Mid-West Conf. on Fluid & Solid Mechanics. Co-sponsored by U. of Tex., A.I.Ch.E. & others. Tech. Chmn.: M. J. Thompson, U. of Tex.

• St. Paul Minn. Sept. 27-30, 1959. Hotel St. Paul. A.I.Ch.E. National Meeting. Tech. Pres. Chmn.: A. J. Madden, Jr., Univ. of Minn. See p. 130.

• Portland, Ore. Oct. 10-12, 1959. Multnomah Hotel. Wood Ind. Conf. sponsored by ASME, FFRS & A.I.Ch.E. (Wash.-Ore Sect.)

• New York, N. Y. Oct. 27, 1959. Hotel New Yorker. Annual All-Day Symposium, New York Section, A.I.Ch.E. Customer-Contractor Relations (Panel); Computer Control Through Process Dynamics; New Separation Techniques.

• Galveston, Texas. Oct. 30, 1959. Moody Convention Center. 14th Ann. Technical Meeting, South Texas Section. A.I.Ch.E. Pres. Chmn.: R. D. Hornbeck, Alcos, Rockdale, Tex.

• San Francisco, Calif. December 6-9, 1959. Sheraton Palace. A.I.Ch.E. Annual Meeting. Tech. Pres. Chmn.: C. R. Wilke, Div. of Chem. Eng., Univ. of Calif., Berkeley, Calif. Process Dynamics—E. F. Johnson, Dept. of Chem. Eng., Princeton U., Princeton, N. J. Operations Research—R. R. Hughes, Shell Dev. Co., Emeryville, Cal. Progress and Problems in Jet and Rocket Combustion—C. J. Marsel, NYU, University Heights, New York 53, N. Y. Thermal Recovery of Petroleum—P. H. Poetman, Ohio Oil Co., Littleton, Colo. Fundamental Aspects of Chemical Engineering in the Pulp and Paper Industry—J. L. McCarthy, Dept. Chem. Eng., U. of Washington, Seattle, Wash. Turbulence and Turbulent Mixing—T. Baron, Shell Dev. Co., Emeryville, Cal. Electro-Chemical Engineering—C. W. Tobias, Dept. Chem. Eng., U. of Calif., Berkeley. Cal. Outlook for National Resources—C. Meyer, U. of Calif., Berkeley, Calif. Quality Criteria for Catalytic Cracking Stocks & Methods of Preparation—W. W. Kraft, Lummus Co., 380 Madison Ave., N. Y. 17. N. Y. Fundamental Concepts of Miscible Fluid Displacement—P. H. Poetman, Ohio Oil Co., Littleton, Colo. Financing in the Chemical Industry—C. P. Neidig, White Weld & Co., 123 So. Broad St., Phila., Pa. Selected Heat Transfer Papers—J. G. Knudsen, Ch.E. Dept., Oregon State Coll., Corvallis, Ore. Heavy Water Production Processes—W. P. Bebbington, DuPont, Aiken, S. Car. Special Lecture Series: Process Development by Statistical Methods (all day Sunday, Dec. 6)—G. E. P. Box & J. S. Hunter, Statistical Res. Group, Princeton U., Princeton, N. J. Student Program—D. M. Mason, Stanford U., Calif. Selected Papers—M. Manders, Union Oil Co., Rodeo, Calif.

Deadline for papers: August 6, 1959.

1959—Non-A.I.Ch.E.

• New London, New Hampton, Meriden, (all) N. H. 12 weeks; June 15-Sept. 4, 1959. Gordon Research Conferences on fundamentals of engineering and science. Ref. to: W. George Parks, Conf. Dir., U. of Rhode Island, Kingston, R. I.

• Wash. D.C. Aug. 31-Sept. 3, 1959 Nat. Bur. Stds. 4th International Symposium on Free Radical Stabilization: "Trapped Radicals at Low Temperatures." Ref. A. M. Bass, N.B.S., Washington, 25, D. C.

• Berkeley, Cal. Sept. 3-4, 1959. U. of Cal. Cryogenic Engineering Conference; limited to technical aspects of field only below 150°K (—190°F). K. D. Timmerhaus, Secy. Cryo. Eng. Conf., Dept. Ch.E., U. of Colo., Boulder, Colo.

• Cleveland, O. Sept. 8-12, 1959. Tudor Arms Hotel. International Conf. Standards on Common Language for Machine Searching & Translation, Western Reserve Univ. and Rand Devel. Corp.

continued on page 128

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future meetings

continued from page 124

• New York, N. Y. Sept. 9-10, 1959. 2nd International Congress on Air Pollution. Sponsored by ASME, 29 W. 39th St. New York 18, N. Y.

• Cleveland, O. Oct. 22-24, 1959. Acoustical Society of Amer. Special session on Theoretical & Practical Aspects of Cavitation. 200 word abstracts to H. Shankland, Dept. Physics, Case Inst., Cleveland 6, by July 31.

1960—MEETINGS—A.I.Ch.E.

• Atlanta, Ga. Feb. 21-24, 1960. Hotel Biltmore. A.I.Ch.E. National Meeting. Tech. Proc. Chmn.: F. Bellinger, Georgia Tech, 225 North Avenue N.W., Atlanta 13, Ga. Kinetics—C. D. Holland, Chem. Eng. Dept., Texas A&M. College Sta., Texas. Pesticides—(2 sessions) D. J. Porter, Diamond Alkali, Box 348, Painesville, Ohio. Nuclear Fuel Materials Processing—D. S. Arnold, American Potash & Chem. Co., Henderson, Nev. Petroleum, Turpentine, and Solvents: Rubber and Plastics Applied to Textile Fibers: John Warner, Chem. Div., Goodyear Tire & Rubber, 1485 E. Archwood Ave., Akron 16, O. Biengineering—Radioisotopes; Rockets and Missiles—R. B. Filbert, Jr., Battelle Mem. Inst., 505 King Ave., Columbus, O. Engineering Education: Mineral Engineering—W. A. Koehler, West Virginia U., Morgantown, W. Va. Fundamentals: Selling: By and To Small Plants—J. T. Costigan, Sharples Corp., 501 5th Ave., New York 17, N. Y. Filtration through Porous Media—F. M. Tiller, Dean Coll. of Eng., U. of Houston, Houston 4, Tex. Sterilization of Air & Food—W. B. Harrison, Ga. Tech. Air Pollution; High Pressure & High Temperature—H. R. Batchelder, Battelle Memorial Inst., Columbus 1, O. Mass Transfer Applications in Waste Treatment—W. W. Eckenfelder, Manhattan College, Riverdale, N. Y. 17, N. Y.

Deadline for papers: Sept. 21, 1959.

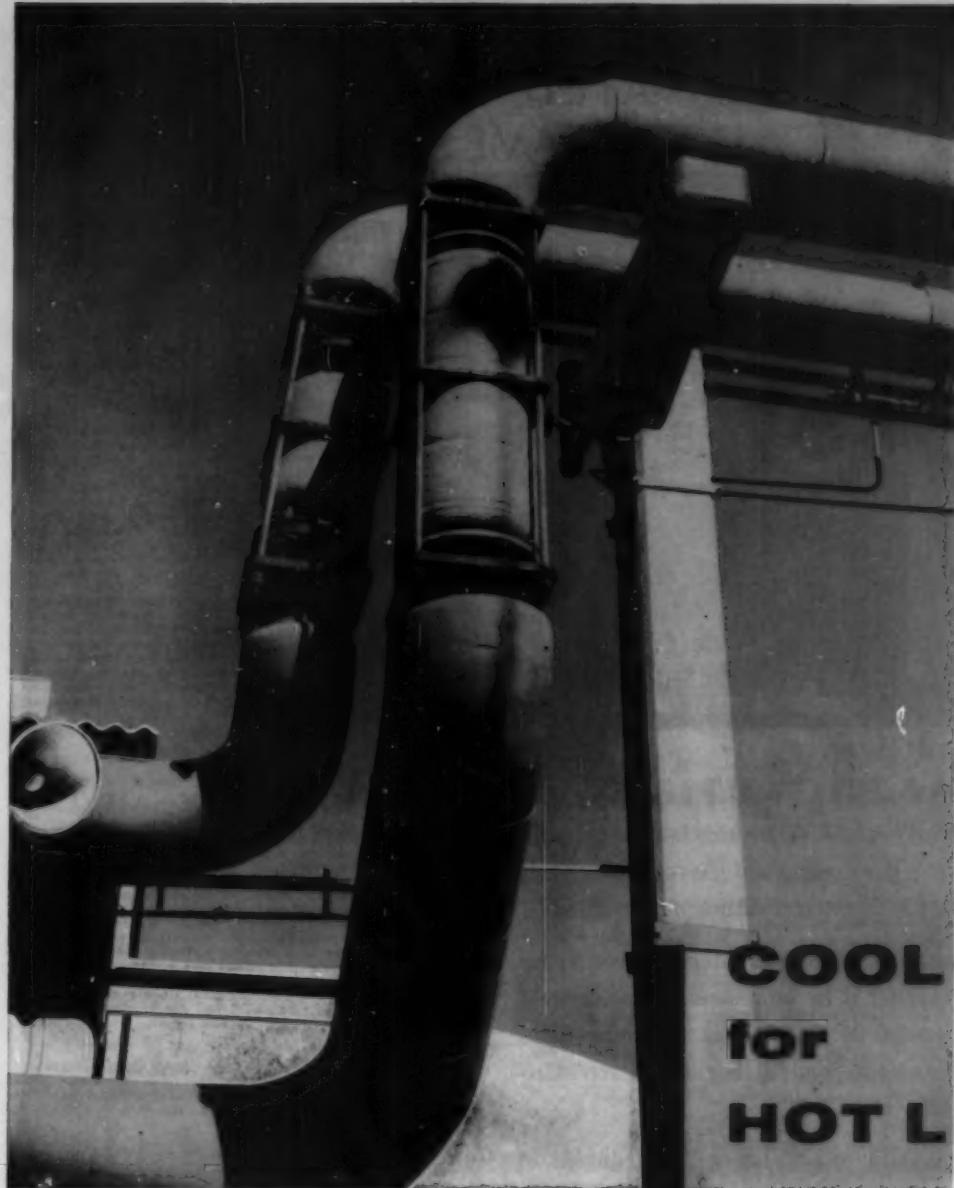
• Mexico City, Mexico, June 19-22, 1960. Hotel Del Prado. A.I.Ch.E. National Meeting—Tech. Proc. Chmn.: G. E. Montes, Northern Natl. Gas Co., 2323 Dodge St., Omaha 1, Nebr. Chemical Engineering in Latin America—John Mayurnik, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. Petroleum and Natural Gas Processing in Mexico & Latin America—F. W. Jessen, Dept. Petroleum Eng., U. of Texas, Austin, Tex. Financing International Projects: Optimization—Pitfalls & Potentials; Chemical Engineering Education in the Americas; Food and Biochemicals—E. L. Gaden, Ch.E. Dept., Columbia U., New York 27, N. Y. Minerals and Metals—D. B. Cughlan, Footh Mineral Co., Berwyn, Pa. Transfer Processes in Two-phase Systems—S. G. Bankoff, Cal. Inst. Tech., Pasadena, Cal. Distillation Equipment—R. Katzen, 3735 Dogwood Lane, Cincinnati, O. Cost Estimation: Selected Papers—J. A. Samaniego, Shell Devel. Co., Emeryville, Cal.

Deadline for papers: January 10, 1960.

• Moscow, USSR, June 1960. 1st Congress of International Fed. Automatic Control. To cover areas of Theory, Hardware & Applications of Automatic Control. U.S. participation sponsored by American Automatic Control Council. Affiliated societies: A.I.Ch.E., ASME, AIEE, IRE, ISA. A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prods., Des Plaines, Ill. Completed papers by July 15, 1959.

• Tulsa, Okla., Sept. 25-28, 1960. Hotel Mayo. A.I.Ch.E. National Meeting. Tech. Proc. Chmn.: K. H. Bachmuth, Phillips Petroleum Co., Bartlesville, Okla. Transport Processes in Petroleum Recovery; Natural Gas & Natural Gas Liquids—R. L. Huntington, U. of Oklahoma, Norman, Okla. Advances in Refinery Technology—W. C. Offutt, Gulf R&D Co., P.O. Drawer 2030, Pittsburgh 30, Pa. Petrochemicals—C. V. Foster, Continental Oil Co., Ponca City, Okla. & H. L. Hayes, Phillips Chem. Co., Bartlesville, Okla. Piping, or Why Buy the Restaurant When All You Need is a Meal—R. E. Weis, Phillips Pet. Co., Bartlesville, Okla. & D. Popovac, Continental Oil Co., Ponca City, Okla. Corrosion & Materials of Construction—W. A. Luse, The Duriron Co., P.O. Box 1019, Dayton 1, O., & M. S. Worley, Black, Sivalls & Bryson, P.O. Box 1714, Oklahoma City, Okla. Statistics and Numerical Methods Applied to Engineering—R. L. Heiny, 2709 Jefferson, Midland, Mich.

continued on page 128



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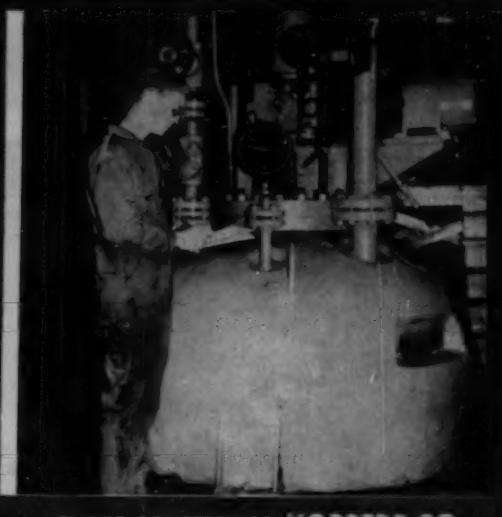


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future meetings

continued from page 126

Air & Ammonia Plant Safety—L. T. Wright, **Refinery & Natural Gasoline Plant Safety: Processing Agricultural Products**—A. Rose, Tex. Eng. Exp. Sta., Tex. A&M. Coll. Sta., Tex. Area Industries, Chemical Reactions Induced or Modified by Radiation—J. J. Martin, Ch.E. Dept., U. of Mich., Ann Arbor, Mich. Conservation & Utilization of Water—F. J. Lockhart, Ch.E. Dept., U. of So. Cal., 3551 University Ave., Los Angeles 7, Cal. **Plastics**—C. S. Grove, Jr., Syracuse U., Syracuse 10, N. Y. & R. L. Tuve, U.S. Naval Res. Lab., Wash. 25, D.C. **Computers as a Management Tool**—R. Ciner, Grace Chem. Co. 3 Hanover Square, New York 4, N. Y. **Non-Newtonian Fluid Mechanics**—A. B. Metzner, U. of Delaware, Newark, Del. **Student Program, Selected Papers**.

Deadline for papers: May 2, 1960.

• **Washington, D. C., Dec. 4-7, 1960.** Statler Hotel, A.I.Ch.E. Annual Meeting, Tech. Prog. Chmn.: D. O. Myatt, Atlantic Research Corp., Alexandria, Va. **Tentative Program framework: Chemical Engineering in Govt. Programs, Agency Oriented: Nuclear Energy, Health and Education; Agriculture: Foreign Assistance Programs; Resources Development; Utilization and Reclamation; Naval Warfare Technology; Land Warfare Technology; Chemical Warfare, and Basic Research, Subject Oriented: Doing Business with the Government; Fluid Particles and Aerosols; Combustion; Materials Degradation; New Process Techniques; Unsteady State Instrumentation; Computer Control of Processing Units; Missiles and Rockets; Design Techniques for Very Large Systems; Information and Communication; Characteristics of Portable and Expendable Plants and Equipments.**

Deadline for papers: July 5, 1960.

1961—MEETINGS—A.I.Ch.E.

• **New Orleans, La. Feb. 26-Mar. 1, 1961.** Hotel Roosevelt, A.I.Ch.E. National Meeting, Tech. Prog. Chmn.: H. L. Malakoff, Petroleum Chem. P.O. Box 8, New Orleans 6, La. **Kinetics of Catalytic Reaction; Brainstorming Technical Problems; Petrochemicals—Future of the Industry; on Gulf Coast; Future Processing Technologies in the Petroleum Industry; Education and Professionalism; Mathematics in Chemical Engineering; Liquid—Liquid Extractions; New Processes in the Area; Water from Sea Water; Materials of Construction; Evaluation of Research & Development Projects; Flow Through Porous Media.**

Deadline for papers: Sept. 5, 1960.

• **Cleveland, O., May 7-10, 1961.** Sheraton-Cleveland, A.I.Ch.E. National Meeting, Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 10, O.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

Computers in Optimum Design of Process Equipment: Chen-Jung Hu, as, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

Solar Energy Research: J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison, Wis.

Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbia, Mo.

Process Dynamics as They Affect Automatic Control: D. M. Boyd, Universal Oil Prods., Dec. Plaines, Ill.

Nuclear Chemical Plant Safety: C. E. Dryden, Ohio State U., Columbus, O.

Nuclear Reactor Operations: R. L. Cummings, Atomic International, P.O. Box 300, Canoga Park, Cal.

Operating Experience with the EBR-2: W. A. Rodger, Argonne Nat. Lab., P. O. Box 299, Lemont, Ill.

Drying: R. E. Peck, Ill. Inst. of Tech. 330 So. Federal, Chicago, Ill.

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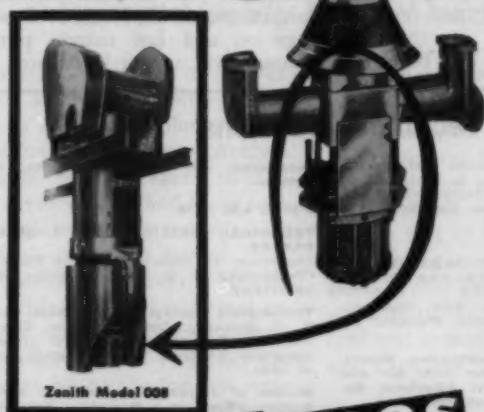
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July 1959 129

St. Paul ...the technical program

ALBERT P. EARLE
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St. Paul, Minn.



Center of interest among chemical engineers at the St. Paul Meeting September 27 to 30, is sure to be the four complete sessions to be devoted to Safety in Air Separation and Ammonia Plants. These symposia will be handled as group discussions of every phase in the design and operation of this type of plant. (See program below for complete list of subjects to be thrown open for consideration). Each topic will be introduced with a 5 or 10 minute talk by an expert in the field, and then opened for general discussion from the floor. The entire discussion will be recorded. However, a transcript of each discussion will be submitted to each speaker for editing before publication. This should lead to a completely off-the-cuff, free-for-all, no-holds-barred exchange of opinions and facts.

A little-publicized aspect of chemi-

cal engineering will see the light of day in the session on Chemical Warfare (Monday morning), presented by staff members of the U. S. Army Corps Engineering Command of the Army Chemical Center, Maryland. The talks will range from the use of models as an engineering tool to the production of colored smoke.

Two management symposia will balance the purely technical aspects of the overall program. On Tuesday morning, L. B. Hitchcock will lead a session on Management of New Product Development which will include talks on such revealing topics as What Management does About New Product Development and the Economics of Innovation, will provide an insight into the workings of the top-management mind and motivation.

The Space Age will also be in the

headlines at St. Paul with the Wednesday morning symposium on Missile Construction Materials. Aside from the intrinsic and extremely topical interest of the subject, chemical engineers are sure to find here much that they will find applicable to other more conventional chemical engineering problems.

The technical program is given below in detail. As we went to press, information was still lacking on several symposia—in particular, those on Molecular Engineering, Mixing, Equipment, Process Dynamics.

We understand from the St. Paul arrangements committee that plans are rounding into shape nicely for the plant tour schedule, the ladies program, and other assorted extracurricular activities. Full details of these goings on and last minute program changes will appear in August.

Three-Day Schedule of Technical Sessions

MONDAY, SEPTEMBER 28

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 1—CHEMICAL WARFARE

Chairman: L. E. Garone, U. S. Army Chemical Corps.

Plant Model—An Engineering Tool. R. E. Kitchin, U. S. Army Chemical Corps. Plant models have become an essential tool in the design, construction, and operation of a chemical plant.

Design Characteristics of Equipment for Helium Leak Testing Toxic Munitions. C. A. Martin, U. S. Army Chemical Corps. Techniques and equipment for in-process inspection of munitions for minute leakages.

Production of Colored Smoke for Munitions. P. E. Fisher, U. S. Army Chemical Corps. The Chemical Corps reveals progress in colored smoke munitions manufacture.

Difficulties Encountered in Nerve Gas Manufacture. W. S. Harmon, U. S. Army Chemical Corps. Study of process, operational, and mechanical difficulties met in break-in operations of chemical plants.

Environments—Their Simulation and Exploration in Test Chambers. A. L. Bloch, U. S. Army Chemical Corps. The storability and use of material anywhere on the earth is a basic military requirement.

TECHNICAL SESSION NO. 4—SAFETY IN AIR AND AMMONIA PLANTS—PART 1—AIR SEPARATION PLANT SAFETY

Chairman: W. A. Mason, Dow Chemical. Asst. Chairman: L. T. Wright, Standard Oil (Indiana).

Group discussions of Subcommittee Report, Air Intake, Compressors for both Air and Ammonia Plants, Silica Gel Adsorbers, Re-boilers and Vaporizers, Instrumentation.

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 5—SAFETY IN AIR SEPARATION AND AMMONIA PLANTS—PART 2—AIR SEPARATION PLANT SAFETY

Chairman: W. A. Mason, Dow Chemical. Asst. Chairman: L. T. Wright, Standard Oil (Indiana).

Group discussions of Construction Materials and Practices, Repairs and Shutdowns, Descriptions and Analyses of Accidents in Air

Separation and Ammonia Plants, Miscellaneous.

2:30 to 4:30 P. M.

TECHNICAL SESSION NO. 7—SELECTED PAPERS

Chairman: C. Geankoplis, Ohio State Univ. Co-chairman: J. D. Lohay, Argonne National Laboratory.

Temperature Control in Gas-phase Reactors. P. O. Shinskey, Olin Mathieson. Design of reactor and temperature control system for gas-phase reactions involving great amounts of heat.

Studies of Intraparticle Diffusion and Conduction Effects in a Gas-phase Catalytic Reactor. R. E. Schlaen, Ohio Oils & N. R. Amundson, Univ. of Minn. Derivation of differential equations of conservation of mass and energy for a spherical pellet.

Extractive Reaction. E. L. Pirt, Univ. of Minn., W. H. Penney, Minnesota Mining & Mfg., & P. Trambouse, Institut Francais du Petrole. How rate of reaction, volumetric efficiency, and reactant conversion of a single-phase batch reaction and of a con-

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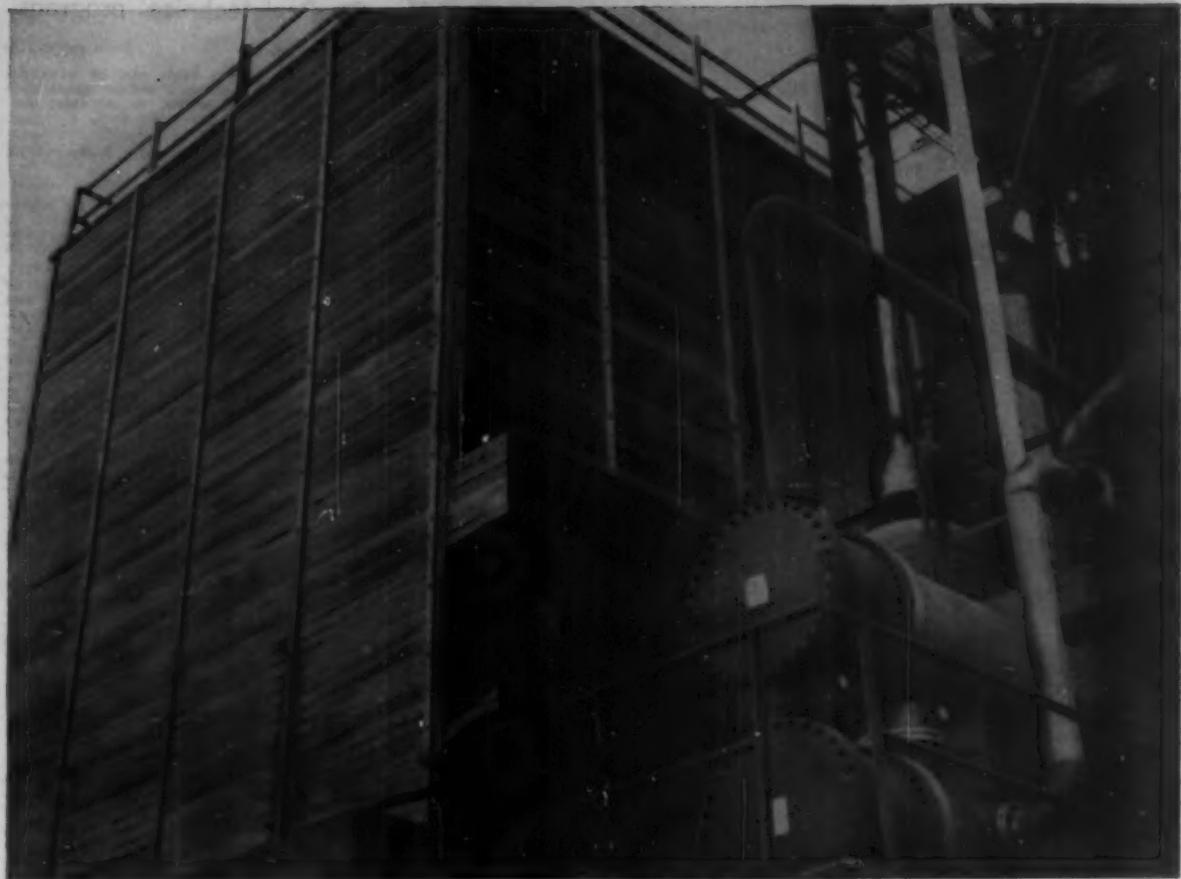


Photo and information, courtesy of Chemical Processing Magazine

Going two years! Nickel Stainless Steel doubles life of nitrogen oxide exchangers

...has already saved thousands with more savings to come

Until recently, corrosion of heat exchangers at the Cooperative Farm Chemicals Association plant in Lawrence, Kansas was an acute problem. Sometimes the exchangers, used to cool nitrogen oxides, had to be completely replaced within a year . . . at a cost of thousands of dollars.

Now comes word that nickel-containing Type 304 stainless steel exchangers . . . the ones shown above . . . have lasted two years. And they are expected to be on-the-job for some time to come. The units were made by Western Supply Company of Tulsa, Oklahoma.

Temperature is reduced 410°F

As a step in the production of 57% nitric acid, the units take nitrogen oxides derived from ammonia oxidation and cool them from 500°F to 90°F. Each exchanger has 1305 square feet of cooling surface. Surface is obtained with 473, $\frac{3}{4}$ -inch tubes. Tubes are Type 304L stainless steel. With the exception of channel side and external bolting, shells are also Type 304.

Other savings

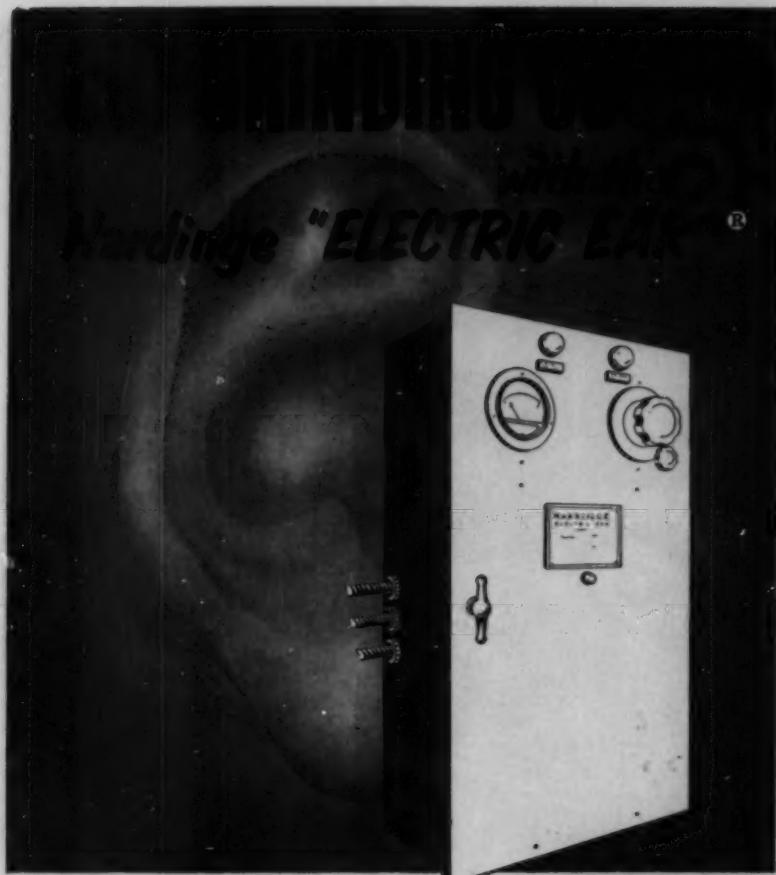
In addition to eliminating early replacement cost, the use of nickel-

containing stainless steel in these exchangers is materially reducing general maintenance and down time.

In thousands of other chemical processing applications, nickel-containing stainless steels are doing as much or more. Contact your fabricators about these useful steels. Or go to the producers of stainless steel for information. Ask them to suggest places where a stainless steel specification can save money in your plant.

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St. Paul technical program

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tinuous-flow stirred tank can be enhanced by deliberately adding a second phase such as an immiscible solvent or an inert gas.

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 8—PHYSICAL PROPERTIES OF LIQUIDS.

Chairman: S. E. Isakoff, Du Pont.

A Corresponding States Correlation for Higher Molecular Weight Substances. A. Bondi & D. J. Simkin, Shell Development. A correlation containing readily measurable properties as reducing parameters.

Liquid, Gas and Dense Fluid Viscosity of Propane. K. E. Starling, B. E. Eakin, and R. T. Ellington, Inst. of Gas Technology. Experimental viscosity data for pressures of 100 to 6,000 lb./sq. in. abs. Methods for extrapolation to higher temperatures and pressures.

The Viscosity of Liquid Mixtures. R. A. McAllister, Lamar State College of Technology. A theory based on Eyring's Theory of Absolute Reaction Rates.

Reduced Thermal Conductivity Correlation for Ethylene: Its General Application to Gaseous Aliphatic Hydrocarbons and Their Derivatives. E. J. Owens & G. Rhodes, Northwestern Univ. An equation and procedure for calculation of thermal conductivities from a single experimental value and knowledge of the critical temperature.

An Experimentally Verified Theoretical Study of the Falling Cylinder Viscosimeter. J. Lorenzen, G. W. Swift, & F. Kurata, Univ. of Kansas. A theoretical analysis of laminar flow in the annulus of a falling cylinder viscosimeter leads to a new method of representing calibration data.

TUESDAY, SEPTEMBER 29

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 9—CRUSHING—THEORY AND PRACTICE.

Chairman: Not yet announced.

Slow Compression Crushing of Single Particles of Glass. W. J. Kenny, Remington Rand & E. L. Piret, Univ. of Minn. Determination of surface area, energy input, and heat generation.

The Dissipation of Energy in Single Particle Crushing. R. H. Zeleny, Michigan State Univ. & E. L. Piret, Univ. of Minn. Measurement of new area, heat produced, surface energy, energy input to the sample, and energy lost to plastic deformation of the steel crusher surfaces.

Evaluating the Resistance of Abrasive Grits to Commination. D. E. Cadwell & E. J. Duwell, Minnesota Mining and Mfg. Development of a commination resistance index based on screen analysis of the crushed product.

The Ball Mill for Pigment Dispersion and Grinding. R. H. Jobens, Patterson Foundry and Machine. General principles used for wet grinding to small size apply equally well to dispersion of pigments into paint, ink, and coatings in a ball mill.

TECHNICAL SESSION NO. 10—MANAGEMENT OF NEW PRODUCT DEVELOPMENT.

Chairman: L. B. Hitchcock, Lauren B. Hitchcock Associates.

What Management Does About New Product Development. L. A. Hatch, Minnesota Mining and Mfg. Management's first responsibility is to establish realistic policies toward building profits. What factors influence the choice of new products as the preferred source of future profits?

Who Develops New Products? W. E. Kuhn, Texaco. Communication of ideas and recommendation and evaluation of their need and potential are basic to the development of new products.

When is the Development of a New Product Complete? F. A. Soderberg, P. C. Huyck & Sons. Discussion of factors which determine the transfer from development to sales.

Developing New Products by Acquisition. L. B. Hitchcock, Lauren B. Hitchcock Associates. A buyer's market is diverting creativity to small companies as a new road to commercialization.

The Economics of Innovation. W. J. Riley, Food Machinery and Chemical.

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St. Paul technical program

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TECHNICAL SESSION NO. 12—SAFETY IN AIR SEPARATION AND AMMONIA PLANTS—PART 3—AMMONIA PLANT SAFETY.
Chairman: W. A. Mason, Dow Chemical.
Asst. Chairman: L. T. Wright, Standard Oil (Indiana).

Group discussions of Hydrogen Production, Compressors, High Pressure Equipment, Ammonia Storage.

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 13—SAFETY IN AIR SEPARATION AND AMMONIA PLANTS—PART 4—AMMONIA PLANT SAFETY.

Group discussions of Tank Cars and Trucks, Preparation for Repairs, Description and Analysis of Ammonia Plant Accidents, Materials of Construction, Personnel Safety in Air Separation and Ammonia Plants.

2:00 to 4:30 P. M.

TECHNICAL SESSION NO. 15—SELECTED PAPERS.
Chairman: C. Grankoplis, Ohio State Univ.
Co-chairman: J. D. Lohay, Arsonne National Laboratory.

Mass Transfer Efficiency of Packed Columns, D. Cornell, W. G. Knapp, H. J. Close, & J. R. Fair, Monsanto. Correlations of packed column gas-liquid mass transfer, based on the two-film model.

A New Correlation for Mass Transfer in the Flow of Gases Through Packed Beds and for the Psychrometric Ratio, E. J. Lynch & C. R. Wilke, Univ. of Calif.

Heat-Transfer Characteristics of Evaporative Coolers, R. O. Parker & R. E. Tresbal, New York Univ. A new mathematical model for evaporative coolers.

Concurrent Mass Transfer to Liquid Films, D. E. Collins, Dow Chemical, & W. H. Tucker, Purdue Univ. Comparison of concurrent and counter-current flow of a gas and liquid in a wetted-wall column.

WEDNESDAY, SEPTEMBER 30

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 17—COALESCENCE.
Co-chairman: R. C. Kintner & A. H. P. Skelland, Ill. Inst. of Technology.

Limited Coalescence Emulsions Stabilized by Bentonite, R. M. Wiley, Dow Chemical. A little known class of emulsions having unusually sharp drop-size distributions, in which average drop size is readily predictable and controllable over a very wide range.

Coalescence of Liquid Drops with Flat Liquid-liquid Interfaces, G. E. Charles, Esso Research and Engineering, & S. G. Mason, McGill Univ. and Pulp and Paper Research Inst. of Canada. Phenomena attending coalescence of liquid drops suspended in an immiscible liquid studied using high speed cinematography, optical interferometry, other techniques.

Effects of Electric Field on Water Droplet Coalescence, G. G. Coyer, Canadian Industries, Ltd., J. E. McDonald, Univ. of Arizona, F. Baer & R. Braham, Univ. of Chicago. Measurement of droplet coalescence efficiencies with high-speed photographs of an inverted Rayleigh jet.

Growth and Interaction of Droplets in a Vapor Stream, A. Lieberman, J. Rosinski, and T. Engelhart, Armour Research Found. Examination of droplet sizes resulting when an initially monodispersed nuclei cloud is introduced into a turbulent vapor stream jetting into still air.

TECHNICAL SESSION NO. 18—MISSILE CONSTRUCTION MATERIALS.

Chairman: E. Landis, Lockheed.

Thermal Protection for Re-Entry, I. J. Grunfest & L. H. Shenker, General Electric. High temperature problems in protection of long-range missiles from thermal damage during re-entry into the atmosphere.

Missiles, Material Selection and Metallurgical Research, W. S. Lyman, Battelle. Development of alloys and processes to meet new requirements.

Missile Construction Materials, E. Scala, AVCO Corp. Use of composites to meet minimum weight requirements.

continued on page 134



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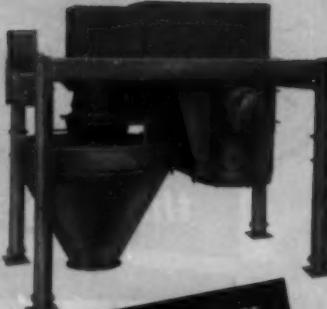
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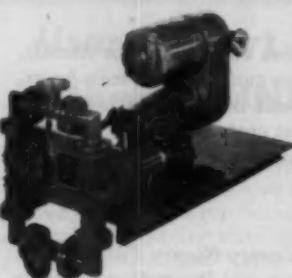
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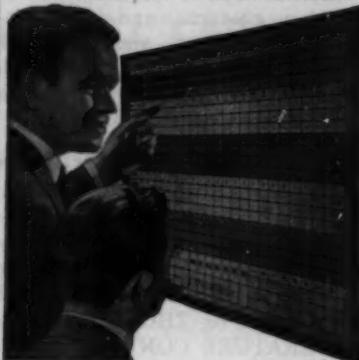
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St. Paul technical program

from page 133

TECHNICAL SESSION NO. 19—CHEMICAL ECONOMICS—UNIT PROCESS

Chairman: M. H. Baker, M. H. Baker Co.

Chemical Engineering Know-How vs. Know-Why, B. D. Kirkpatrick. Chemical Engineering. An adequate definition of chemical engineering must emphasize the determining importance of economics as a guide to the successful practice of our profession.

Chemical Economics as a Tool in Market Analysis, R. W. Schramm, Southern Nitrogen. How to evaluate competitive products and to optimize plant location with respect to raw materials, existing capacity, markets to be served.

Working Capital in New Plant Construction and Operation, J. B. Weaver & P. S. Lyndall, Atlas Powder. A revised definition of working capital for the purpose of capital expenditure justification.

Chemical Economics as a Guide to Management, O. K. Nelson, Archer-Daniels-Midland. Chemical economics as applied to a multi-industry corporation for guiding management decisions relative to investments.

Systematic Research, F. P. Vance, Phillips Petroleum. Systematization of research effort via the methods of mathematical statistics.

2:00 to 3:00 P. M.

TECHNICAL SESSION NO. 21—LONGITUDINAL DISPERSION EFFECTS

Chairman: J. R. Fair, Monsanto.

Taylor Diffusion in Tubular Reactors, J. Coste, D. Rudd, & N. R. Amundson, Univ. of Minn. When the reaction rate is a function of the temperature and one concentration, the system is described by two second order nonlinear ordinary differential equations.

Gas Mixing in a Fluidized Bed, R. L. Pigford & R. C. Romano, Univ. of Del. Residence time distribution functions of the gas in a fluidized bed calculated from frequency response measurements.

Transient Response Study of Gas Flowing Through Irrigated Packing, F. DeMaria, American Cyanamid, & R. R. White, Univ. of Mich. Residence-time distributions of gas flowing through irrigated packing determined using transient tracer experiments.

Applications of the Diffusion Model to Longitudinal Dispersion in Flow Systems, G. A. Latimer & F. D. Stockton, Monsanto. Outflow residence time probability density for the industrially important case in which the ends of the flow vessel approximate perfect diffusion barriers and contain the feed and discharge ports.

A Penetration-Mixing Model of Fluid-Particle Mass Transfer in Fixed Beds, J. J. Carberry, Du Pont. Higbie's penetration theory used to predict fluid-particle mass transfer rates in fixed beds.

2:00 to 4:30 P. M.

TECHNICAL SESSION NO. 22—SELECTED PAPERS

Chairman: C. Geankoplis, Ohio State Univ. Co-chairman: J. D. Lohay, Argonne National Laboratory.

Production of Heavy Water, W. P. Bebbington & V. B. Thayer, Du Pont. Use of heavy water to moderate the nuclear reactors of the Savannah River Plant.

Miniature Hydroclones as Slurry Concentrators, F. C. Engel, Westinghouse, & J. Weiman, Nuclear Development Corp. Miniature hydroclones evaluated for use with thorium-232 slurries.

Equipment for Measurement of Interval Temperatures in Screw Reactors, F. M. Tetsel, J. A. Williamson, A. E. Abbott, & R. L. Maddox, National Lead. The techniques used to measure the elevated temperatures in a large screw-type reactor used for contacting uranium trioxide with hydrogen.

Materials of Construction for Phosphoric Acid Service, E. Pelitti, Chemical Construction Corp. An exhaustive survey of materials of construction.

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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

industrial news

Scotland looks for Chemical industry

Information on Scotland as a manufacturing location offered to U. S. industry by The Scottish Council.

Chemical companies in the United States interested in Scotland as a manufacturing location can get all the information they need for a preliminary assessment from The Scottish Council, without sending representatives over.

The Scottish Council, in Edinburgh, is an organization supported mainly by Scottish industry, with the object of promoting industrial expansion. Services offered include supplying preliminary information such as labor and raw material costs, site availability, building costs, rental and amortization facilities. The Council also arranges itineraries for later visits, and takes care of introductions to appropriate government departments and individuals. Help on manufacturing, export, and marketing problems are also included in the assistance offered by The Council.

Plans to expand the recently acquired nitrogen facilities at Mississippi River Fuel Corp.'s plant at Festus, Missouri, are proceeding at Armour & Co. With the purchase of the new facilities, Armour Agricultural Chemical Co., a division of the company, was formed. A research and development group is being set up to investigate application of various nitrogen solutions.

A company to manufacture polyethylene film and film products in Hawaii was formed by Pacific Chemical and Fertilizer Co. of Honolulu, and Dow Chemical. The firm, to be known as Hawaiian Extruders, will be located in Honolulu.

A liquid epoxy resins plant with a rated capacity of 15 million pounds annually has gone on-stream at Marietta, Ohio. Beginning of production at the new Union Carbide Plastics plant coincides with a company policy of expansion in the epoxy resins field.

Facilities to produce sodium tripolyphosphate and phosphoric acid have been completed at Lecheria, Mexico, by Monsanto Mexicana. Believed to be the first Mexican manufacturer of these chemicals, the Monsanto Chemical subsidiary will supply the Mexican detergent industry, and phosphoric acid in both food and industrial grades to industrial users.

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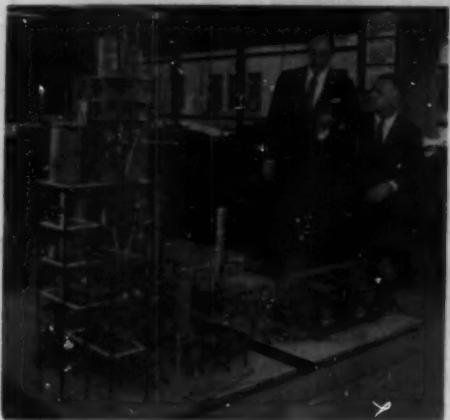
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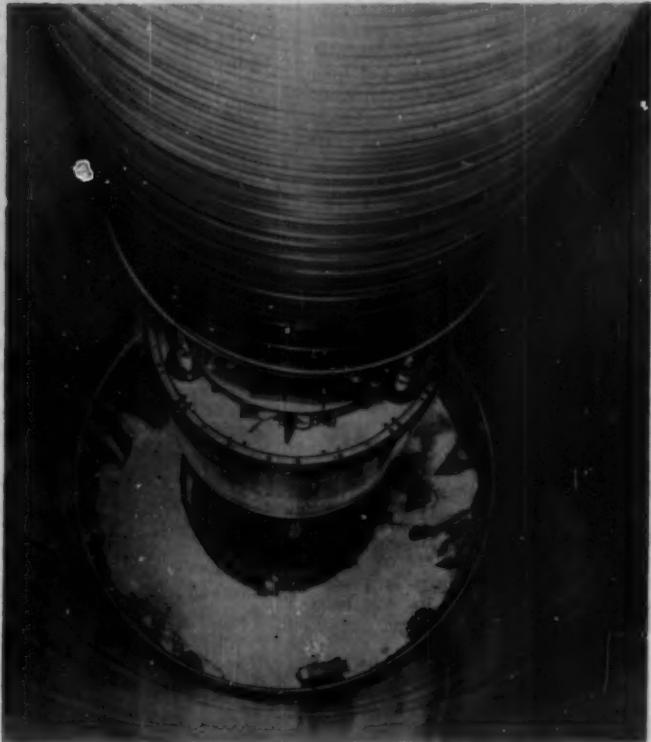
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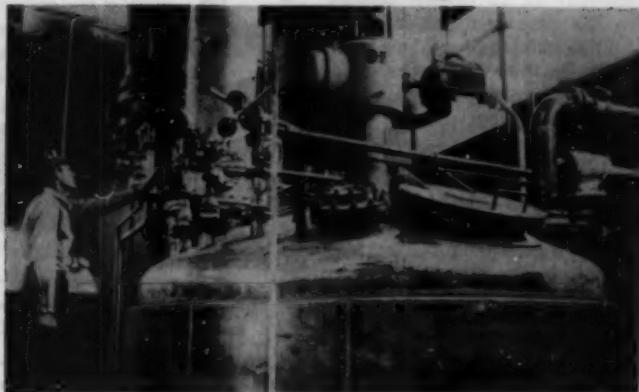
Exact model of SunOlin's new urea plant was built by M. W. Kellogg, cost \$30,000. SunOlin's president, J. I. Harper (right) and vice president, S. S. Johnson, inspect the model. Plant is now under construction at North Claymont, Del.



The \$3,600,000 Hooker Research Center on Grand Island in the Niagara River was recently dedicated with New York's Governor Rockefeller as the main speaker at the ceremonies.



This new low-energy 12 MeV tandem Van de Graaff accelerator at Britain's Atomic Weapons Research Establishment, Aldermaston, Berks, is the largest of its kind in the world. For size, note technician at right looking up.



Close-up of a Dewey and Almy (W. R. Grace) butadiene-styrene reactor showing some of the control mechanisms which govern the manufacturing of rubber latex compounds. In essence the reactor is a giant pressure cooker.

THE COOPER-BESSEMER CORPORATION



L. A. Ffrench (left), Cooper-Bessemer sales engineer, discusses his company's wares with H. C. Waters of International General Electric (center) and fellow Cooper-Bessemer sales engineer S. de Garmo.

At the 5th World Petroleum Congress Exposition At the New York Coliseum in June



Equipment manufacturer Dorr Oliver had W. J. Riker, industrial area sales representative, and Howard V. Vecsey on hand to discuss engineering problems.



Spiraxial compressor model (center) was a feature of Dresser Industries' booth at the Exposition. Map shows the world-wide operations of the equipment firm.



Attention-getter was Griscom-Russell's model of its steam generator for the Enrico Fermi atomic power plant at Monroe, Mich. Liquid sodium heated, the unit is a once-through steam generator.

Peninsular Florida Two-day Meeting

The backbone of any national engineering society is the activity of its local sections, said F. J. Van Antwerpen, secretary of the Institute, in his address to the banquet which culminated the Peninsular Florida Section's (Robert B. Bennett) Second Annual

Meeting. Held at Daytona Beach in June, the two-day meeting presented a full scale technical program.

Theme of F. A. O'Neill's first session was *Economics and Chemical Engineering*. The essential probability theory required for solving certain

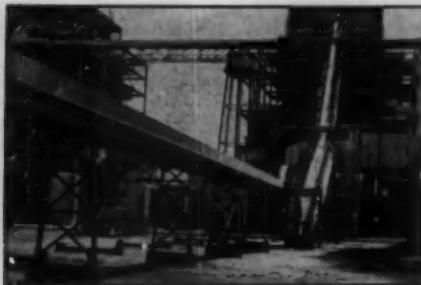
types of real economic problems was developed by E. P. May, University of Florida, in his talk on *Economic Analysis and Uncertainty*. Mathematical models for many economic analyses must consider the characteristic uncertainty (inherent variability) of the real world. Quantitative consideration of such uncertainty requires the application of stochastic principles. The probability theory was applied to the problem of determining the optimum number of items to stock under the conditions of low cost purchase price plus storage costs, versus a premium price to be paid for additional items needed during a high demand period. Application of the theory was demonstrated by an example problem. The Monte Carlo technique is another way to solve the same problem.

Economics of Plant Expansion and Diversification, Robert Shelter, International Minerals and Chemical. The importance of comparing costs of increasing production in the existing plant with low equipment costs, versus the costs of building additional capacity was stressed.

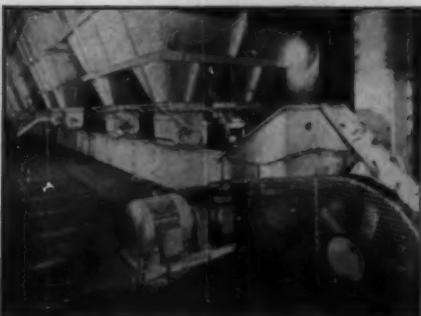
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F. J. Van Antwerpen tells Peninsular Florida that local sections are vital.

Corrosion Problems and their Solution in the Design and Construction of a Tall Oil Springing Plant, E. B. Loyless, Jr., St. Regis Paper. This paper gave complete details of plant planning, construction and operation to reduce the sulfuric acid corrosion problem.

Improved Alkaline Pulping — A Chemical Engineering Problem, M. R. Shaffer, University of Florida. A pilot plant is being built to continuously cook three tons per day based on a new theory of pulping. Wood is pulped by chemically removing the lignin from the outside of fine shredded chips rather than by penetration

continued on page 140

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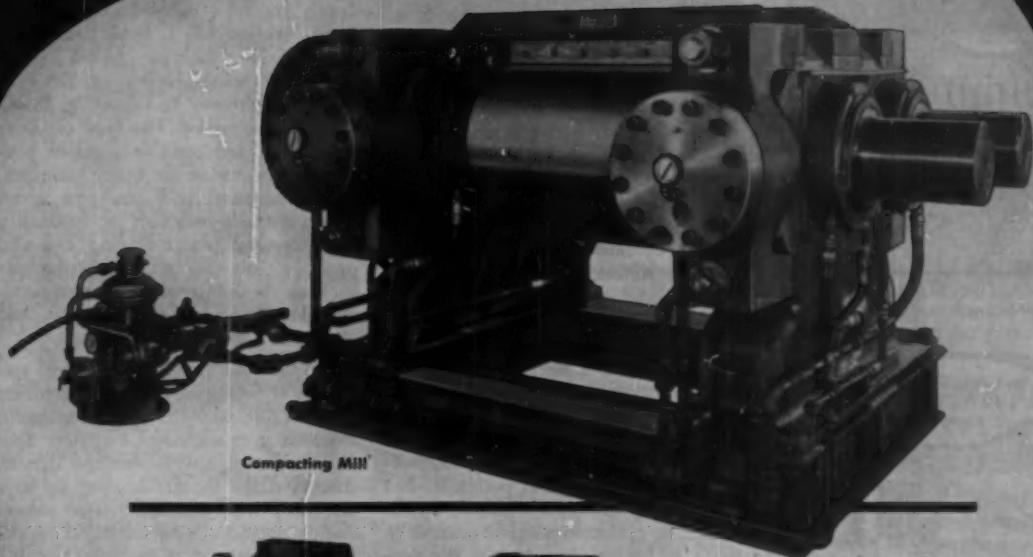
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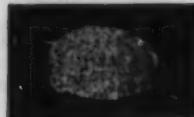
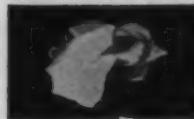
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local sections

from page 138

of the pores of large cellulose chips. This approach has made possible the new type of continuous pulping developed at the University of Florida. Yields are increased, while time, chemical consumption, and equipment investment are reduced.

The general paper session headed by H. O. Grant, with *A New Approach to Batch Rectification Calculations*, C. E. Huckaba, University of Florida. Calculation is based on actual weights rather than moles, and gives more satisfactory results, he said.

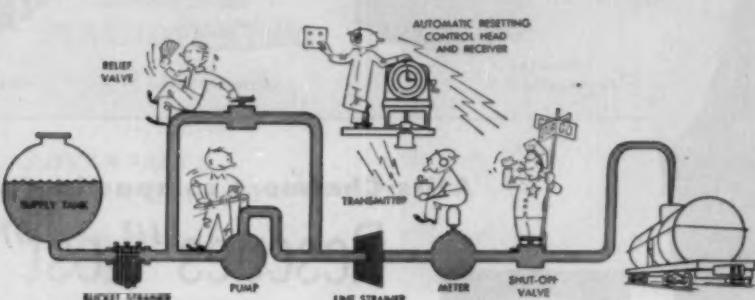
The "Creslan" Acrylic Fiber, R. B. Latimer, American Cyanamid Florida facilities and processes, and methods of use, were described. The importance of prolonged large pilot plant operations was stressed.

Conduct of an Air Pollution Control Monitoring Program, C. R. McHenry. Not only is it important for a plant to protect itself by a monitoring system for possible pollution, but background information should be obtained on pollution already present in the area before the plant is put into operation.

New Jersey Symposium

Solids mixing and continuous processing were under discussion at the Tenth Annual Symposium of the New Jersey Section (R. J. Boyle), in May. The all-day meeting heard J. J. Fischer, Patterson-Kelley, on the *Pre-testing Approach in Choosing Solids Mixing Equipment*. The type of operations that are most in need of pre-testing, because of the many variables, were discussed, and examples given which not only establish the suitability of equipment before buying, but also produce unexpected improvements such as combining several operations, stimulate improved formulations, and eliminate prior processing steps.

On the "continuous processing" end of the eight-paper meeting, members heard a talk on *Batch and Continuous Processing as a Design Engineer Sees It*. Roy Sweet, Singmaster and Breyer, discussed the factors leading up to a decision, with examples from recent design projects. He mentioned capital costs, operating costs, and quality control.



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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

About 100 senior high school students, selected for their interest in a career in chemical engineering, attended the Third Annual Career Day Program of the Coastal Bend Section (John R. McKeeen) in April. The students got a first hand view of the kind of work performed by people in the field, when they toured the Columbia-Southern Chemical plant in Corpus Christi, Texas. Accompanied by local section members from other plants, the students viewed a film on the graduating chemical engineer and his first job, and heard a talk on *What Do You Want To Do*, by the personnel director of Delhi-Taylor Oil.

Also Meeting

Jerry McAfee discussed industry's stake in professional development at the Pittsburgh Section (G. J. Haddad) joint meeting in June with A.S.E.E. . . . Plant tours were the order of the day in April at several sections: Knoxville-Oak Ridge (T. Shapiro) saw the Tennessee Eastman plant in Kingsport. . . . Western New York (Reed E. Garver) saw International



The Texas Chemical Engineer, new magazine written and edited by the A.I.Ch.E. student chapter at the University of Texas, is checked by its editor, Maurice Doke (r), William Cunningham, chemical engineering faculty member, and Don A. Reed (l), president of the student chapter.

Breweries in Buffalo. . . . The Memorial Phoenix Project at the University of Michigan was viewed by the Detroit Section (Clifford Armstrong). The project includes seven campus laboratories for atomic research, including the Ford Nuclear Power Reactor. . . . South Texas Section (W. G. Domask) toured Mastic Tile Corp. in Houston.

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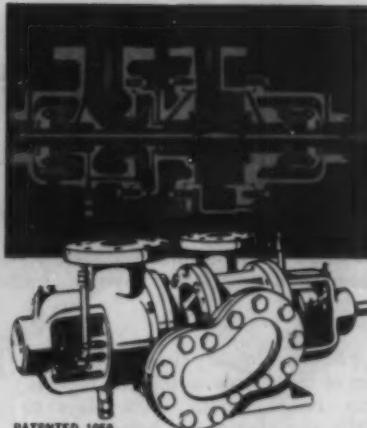
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July 1959 141

Spray drying proves out in ceramics, catalysts

Installations at Minneapolis-Honeywell and Girdler Catalysts show time and labor savings, better quality control.

Fifty-five to sixty-five percent slurries of from three to thirteen ingredients, ranging from 100% clays to 100% non-plastics are being successfully spray dried at Minneapolis-Honeywell in a specially-designed spray dryer (stainless steel, 4½ ft. in diameter) made by Bowen Engineering. The new installation, which has replaced a oven-drying system, meets the need, according to Honeywell, for production of uniform, spherical, free-flowing, easily-pressed particles for dry pressing of ceramic products. Maximum batch introduced into the dryer is 400 lb. at a rate of 80 lb./hr. Minimum production batch is approximately 50 lb.

Chief materials processed on a production basis are alumina, zircon, steatite, barium titanates. (A wide range of other ingredients have been spray-dried on a research basis).

Materials to be dried are first ball-milled for homogeneity. From the ball mill, they are pumped into a 110-gallon feed tank which is under constant agitation to keep the constituent of the slurry in suspension. From here, the slurry is fed to the dryer where it is fed, countercurrently, through one of three specially-designed, two-fluid atomizing nozzles, operating under various pressures, depending on type and rate of feed. The lower the pressure, the larger the granules, and vice versa.

The atomized particles are sprayed violently upwards into the drying area but, before the droplets touch the chamber top, they begin their rapid descent to discharge, undergoing almost flash dehydration in the chamber. Residence time is a few seconds at most. Drying air enters at the top of the drying chamber, at temperatures between 600 and 700°F. At the discharge point, the temperature is approximately 300° less. Both temperatures are pre-set and held within five degrees with pneumatic controls.

In the Minneapolis-Honeywell installation, complete changeover between different compatible charges takes about twenty minutes. When a

previous slurry could act as a contaminant to the next, a several-hour cleanout, including ducts and nozzles, is necessary.

Catalyst application

Three processing steps (filtration, steam drying, and granulation) have been replaced by an automatically-controlled spray drying process in the catalyst preparation plant of Girdler Catalysts in Louisville, Ky. The spray dryer, also made by Bowen, has a diameter of 10 in., and is capable of handling 300 lb./hr. of solids.

After oxide preparation—precipitation and purification under controlled conditions—the chromium and iron oxides along with the physical and chemical additives required in the end product are in a carrier liquid, usually a 20% slurry.

The pre-heated slurry is pumped to the spray dryer, where it is introduced at a temperature of 120°F by a centrifugal disc, rotating at 9,000 to 11,000 rev./min. The disc is a sharp-edged stainless steel wheel, ceramic-coated. The primary purpose of the sharp edge is the control of atomization, which in turn determines



Figure 1: Spray drying installation at Minneapolis-Honeywell working on production of ceramics.



Figure 2: Preparation of water gas shift catalyst by spray drying at Girdler Catalysts. In foreground is filter press, part of the equipment replaced by new technique.

the particle size range of the dried product. The slurry enters the drying chamber as minuscule droplets, each enclosing an oxide particle. Depending on the solids concentration of the slurry, the inlet temperature in the chamber is from 900 to 1,000°F. At the point of outlet, the temperature is maintained at from 300 to 400°F, or a temperature differential of 600°F.

Contamination limiting factor

Because of the ever-present danger of cross contamination, use of the 10 in. spray dryer at Girdler Catalysts has been limited to one product—a water gas shift catalyst. While the unit has been tried and has performed satisfactorily on other catalysts, the need for a major cleanout between each different run would negate completely the benefits of product diversification.

Boron based high-energy fuel, HiCal, will be supplied to the U. S. Air Force for a classified military project. Under a contract recently completed between the Air Force and Callery Chemical, delivery of the fuel begins immediately from the firm's Lawrence, Kansas, plant.

Consolidation of the chemical engineering and chemistry staff at Armour Research Foundation under one roof will take place when the new \$3½ million chemical research building is completed at Illinois Institute of Technology in mid-1961.



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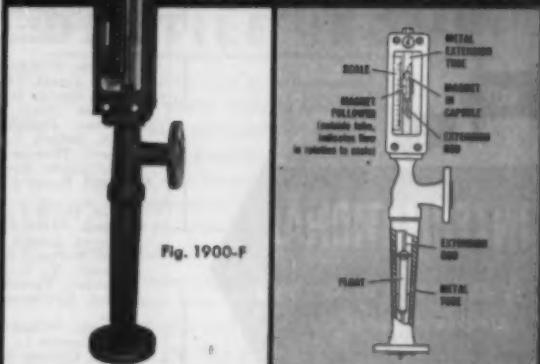
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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

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144 July 1959

A. I. Ch. E. candidates

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before August 15, 1959, at the office of the Secretary, A.I.Ch.E., 26 West 45th Street, New York 36, N. Y.

MEMBERS

Chainie, George W., The Hague, Netherlands
Clauson, W. W., Sacramento, Calif.
Crowley, Ralph P., Bountiful, Utah

Demers, Alfred J., Philipsburg, Pa.
Dimukas, Carl L., Jr., Beaumont, Texas
Duffy, Bernard J., Jr., Sugar Creek, Mo.

Irish, E. R., Richland, Wash.

Kilmer, J. W., Tulsa, Okla.
Kruder, George A., Penfield, N. Y.

Mackay, Johnstone S., Pittsburgh, Pa.
Malone, Albert V., Palestine, Ill.
Moore, Guy L., Jr., Odessa, Texas

Oliver, Earl D., Oakland, Calif.

Raatz, William A., Richmond, Calif.

Ryan, John D., Charleston, W. Va.

Sandin, Carl R., Wood River, Ill.
Schuler, Rudolph W., Kettering, Ohio
Stinson, D. L., Pittsburgh, Pa.

Stobaugh, Robert B., Jr., London, England

Warrel, V. Morgan, Idaho Falls, Idaho
Weatherby, J. J., Denver, Colo.
Webber, W. F., Minneapolis, Minn.

Willie, J. H., Bryn Athyn, Pa.

Young, David A., Kansas City, Mo.

ASSOCIATE MEMBERS

Alievitch, Jack, Little Neck, N. Y.

Barrett, David A., II, South Milwaukee, Wis.
Baumann, John C., Hebron, Ohio

Berghane, Charles A., Jr., Aruba, N. W. I.
Bickford, Calvin F., Lisbon Falls, Maine
Bizzano, Joseph D., Jr., Milwaukee, Wis.

Black, James P., Brooklyn, N. Y.
Blondell, John V., Arlington, Va.

Book, Bro. A., Gerald, S.C., Riverdale, N. Y.

Bosch, Lloyd J., Jr., Luling, La.

Bowie, Lowell C., Cincinnati, Ohio

Brandon, Henry J., Jr., Chicago, Ill.

Bresa, Robert J., Rahway, N. J.

Brown, G. Edward, Arlington, Va.

Bryan, John D., Ponca City, Okla.

Bulletin, Richard C., West Chester, Pa.

Clements, William C., Jr., Nashville, Tenn.

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Contractor, Lloyd, Wilmington, Del.

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Cuffel, Robert F., Los Angeles, Calif.

Culbert, Thomas B., Niagara Falls, N. Y.

Cunningham, Robert E., Houston, Texas

Currier, Royce A., Tulsa, Okla.

Davies, David S., Stamford, Conn.

DaVinci, Anthony P., Trainer, Chester, Pa.

DeMarco, Joseph R., Reserve, La.

Dillon, Bernard J., Jr., Cross Point, Ind.

Dimiceli, V. E., Port Arthur, Texas

Dowdell, Vernon, Chicago, Ill.

Dotson, Lawrence E., Parkersburg, W. Va.

Edwards, William R., Baytown, Texas

Etel, George L., Jr., Ellerson, Va.

Eldred, Charles R., Sulphur Springs, Ark.

Enderle, H. W. L., Jr., El Dorado, Ark.

England, Edward D., Yonkers, N. Y.

Epperson, E. R., Houghton, Mich.

Eusebio, Bienvenido C., Boston, Mass.

Fanning, Robert J., Ponca City, Okla.

Ferreira, Djalma, Lafayette, La.

Flower, Arthur, Lancaster, N. Y.

Fontenot, Ronald C., Eunice, La.

Foster, James Quentin, Baytown, Texas

Frederickson, Arnold G., Minneapolis, Minn.

Fusco, Theodore M., Sewickley, Pa.

Gale, Roger J., Bryn Mawr, Pa.

Garabedian, George, Arlington, Mass.

Gaston, Jon Michael, South Charleston, W. Va.

Gavin, Joseph H., Everett, Mass.

Ginson, Ronald W., Kansas City, Mo.

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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

A I Ch. E candidates

Goldstein, Sidney P., Brooklyn, N. Y.
 Graves, Jo A., Jr., Baton Rouge, La.
 Gruber, A. John, Philadelphia, Pa.
 Gurney, Donald, Jr., Chicago, Ill.
 Gwiazda, Karl E., Chicago, Ill.
 Haff, Karl W., Spring Grove, Va.
 Hamburger, Aaron S., Grand Island, N. Y.
 Harrison, William L., Prairie Village, Kan.
 Havensrite, A. L., Stillwater, Okla.
 Head, Harlan N., Fayetteville, Ark.
 Heard, Charlie E., Baton Rouge, La.
 Heck, Robert R., Louisville, Ga.
 Henry, John P., Belmax, N. J.
 Holberg, Earl, Portsmouth, Va.
 Holt, Jerry E., Pekin, Ill.
 Hopper, Jack E., Baytown, Texas.
 Hutchinson, A., Three Rivers, P. O., Kan.
 Jameson, D. B., Jr., Allentown, Pa.
 Jones, William G., Pine Hall, N. C.
 Jones, Wray H., Batesville, Ark.
 Keith, Robert M., Falls Church, Va.
 Kennedy, William L., Fort Campbell, Ky.
 Kirby, James L., St. Louis, Mo.
 Kirchner, Robert A., Jr., Lancaster, Pa.
 Kirk, Robert S., Hales Corner, Wis.
 Klubunde, Philip K., New Castle, Del.
 Klein, Herbert P., Baltimore, Md.
 Kaudens, George H., Pittsburgh, Pa.
 Kramer, William H., Richmond, Va.
 Lacey, James J., Bartlesville, Okla.
 Lamb, Charles W., Crosscut, Ark.
 Lamprinakos, John William, Brooklyn, N. Y.
 Leary, Albert W., South Charleston, W. Va.
 Leces, Joseph V., Woodland Hills, Calif.
 Lerman, Michael J., Forest Hills, N. Y.
 Lewis, Elmer R., Corpus Christi, Texas.
 LoBue, Thomas John, Hasbrouck Heights, N. J.
 Longest, Albert W., King William, Va.
 Luke, Norbert R., Marree, La.
 Luis, Herbert M., Peabody, Mass.
 Maher, James E., River Edge, N. J.
 Mangold, Pierre, New York, N. Y.
 Manier, Edward J., Brooklyn, N. Y.
 Mason, Norbert S., Akron, Ohio.
 Mazander, Kenneth L., Hot Springs, Ark.
 McHenry, Edwin John, New Providence, N. J.

Meyers, Larry W., Hot Springs, Ark.
 Moreau, Myron J., Cottonport, La.
 Mounts, Gordon D., Charleston, W. Va.
 Mullin, Robert James, Chicago, Ill.

Nagy, Robert, Woodbury, N. J.
 Nelson, David E., Cleveland, Ohio.
 Northam, Barbara Joan, Glynn, Ill.

O'Connor, E. J., Port Neches, Texas.
 Orr, Don, Cupahoga Falls, Ohio.

Parrott, John W., Huntsville, Ala.
 Parry, John B., Lyndbrook, N. Y.
 Paul, Richard S., Tonawanda, N. Y.
 Pezzatola, Joseph, New Rochelle, N. Y.
 Pinno, George G., Cleveland, Ohio.
 Posner, Ernest Gary, New York, N. Y.
 Price, Gary R., Posen City, Ohio.

Quinn, Herbert B., Jr., Tuscaloosa, Ala.

Reeve, Harold E., Brookfield, Ill.
 Rogan, John, Rochester, N. Y.
 Resser, John J., Jr., Glendale, N. Y.
 Roberts, Robert W., Ponca City, Okla.
 Robinson, W. David, Newark, Del.
 Rosenthaler, James M., Joplin, Mo.
 Ross, Thomas H., Baytown, Texas.

Scroggins, Thomas L., Gravette, Ark.
 Scudder, Bob, Hot Springs, Ark.
 Shrier, A. L., Forest Hills, N. Y.
 Sims, James E., China Lake, Calif.
 Shopp, Alvin, Brooklyn, N. Y.
 Sliger, Arlen G., Berwyn, Ill., N. J.
 Spangler, Gordon W., Kingsport, Tenn.
 Stewart, Charles R., Piggott, Ark.
 Strickland, W. T., Jr., Little Rock, Ark.

Talbot, Frank J., Chicago, Ill.
 Thomas, Vaseline H., Sheffield, Ala.
 Traina, Carl, Brooklyn, N. Y.

Voogd, Jacob, Grand Island, N. Y.
 Wagner, William H., Smithton, Pa.
 Warr, Donald, Smackover, Ark.
 Weinstein, Jack, Freshfield, N. J.
 Willets, Thomas L., Birmingham, Ala.
 Williamson, Robert P., Pensacola, Fla.
 Wilson, Jeff E., Little Rock, Ark.

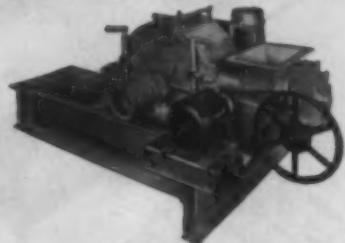
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146 July 1959

AUDITOR'S REPORT

We have examined the balance sheet of the American Institute of Chemical Engineers as of December 31, 1958 and the related statement of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet and statement of income and surplus present fairly the financial position of the American Institute of Chemical Engineers at December 31, 1958, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

F. W. LAFRENCE & Co.
Certified Public Accountants

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

BALANCE SHEET DECEMBER 31, 1958

ASSETS		
Current assets:		
Cash on hand and demand deposits	\$189,607.30	
Cash in savings institutions	124,047.86	
Total	313,655.16	
Less cash in Trust and Special Funds	782.80	\$312,872.36
Investments, at cost including accrued interest	87,523.86	
Less investments in Trust and Special Funds	5,386.25	82,137.61
Accounts receivable, net	53,907.69	
Inventory, at cost	17,142.52	
Prepaid expense advances	8,291.02	
Total current assets	407,761.20	
Deposits	2,081.68	
Total	409,842.88	
Trust and Special Funds:		
Albert E. Marshall Fund	83,008.16	
Frederic C. Bowman Fund	1,198.68	
Ernst Berl Fund	1,886.25	
Research Fund	585.96	6,119.05
Total	91,588.95	

LIABILITIES

Current liabilities:		
Accounts payable	334,687.96	
Deferred income	172,243.61	
Education and print funds	4,068.75	
Surplus	198,842.56	
Total	640,842.88	
Trust and Special Funds (as set forth above)	6,119.05	
Total	641,961.93	

STATEMENT OF INCOME AND SURPLUS FOR THE YEAR ENDED DECEMBER 31, 1958

Income:		
Membership dues	\$298,065.85	
Less allocation to subscriptions	76,381.12	\$221,684.73
Membership entrance fees	11,170.00	
Publications	574,045.82	
Investments	11,920.18	
Other	2,692.41	
Total income	821,512.64	
Expenses:		
Publications	826,147.52	
Salaries and commission	367,815.41	
Retirement plan and federal insurance contributions	10,349.39	
Rent and electric	26,588.94	
Office equipment and machine rental	12,526.42	
Meetings	23,287.97	
Postage, telephone and telegraph	81,611.28	
Printing, stationery and supplies	31,768.52	
Committees	10,982.01	
Participation in professional groups	9,084.06	
United Engineering Center Campaign	4,160.94	
Awards	1,589.92	
Other	12,633.58	
Total	879,260.96	
Less expenses allocated to Heat Transfer Conference and Nuclear Congress	11,518.61	
Total expenses	878,742.35	
Net income for year	88,770.29	
Surplus, December 31, 1957	160,072.27	
Surplus, December 31, 1958	\$198,842.56	

THIRD NATIONAL HEAT TRANSFER CONFERENCE

Following are the papers for the A.S.M.E.-A.I.Ch.E. sponsored Heat Transfer Conference at Storrs, Connecticut, from August 9-12, 1959.

101 Fluid Mechanics and Heat Transfer in Falling Film Systems
A. E. Dukler, Univ. of Houston, Houston, Texas

102 Thermal Conductivity of Some Mesomorphic Compounds
J. B. McCoy* and L. S. Kowalczyk, Univ. of Detroit, Detroit, Mich.
*Present address—Reichhold Chemicals, Inc., Detroit, Mich.

103 Approximate Theory for Film Boiling on Vertical Surfaces
Y. Y. Hsu and J. W. Westwater, Univ. of Illinois, Urbana, Ill.

104 Heat Transfer in Saturated Boiling
Yan-Po Chang and N. W. Snyder, Univ. of Notre Dame, South Bend, Indiana

105 Populations of Active Sites in Nucleate Boiling Heat Transfer
R. F. Gaertner and J. W. Westwater, Univ. of Illinois, Urbana, Ill.

106 The Role of Surface Conditions in Nucleate Boiling
Peter Griffith and J. D. Wallis*, Massachusetts Institute of Technology, Cambridge, Mass.
*Present address—The English Electric Co. Ltd., Whetstone, near Leicester, England

107 Heat Transfer from Pre-mixed Gas Flames in a Cooled Tube
D. W. Sundstrom* and S. W. Churchill, Univ. of Michigan, Ann Arbor, Michigan
*Present address—The Linde Co., Indianapolis, Indiana

108 The Effect of Electrolytic Gas Evolution on Heat Transfer
F. O. Nixon*, W. Y. Chan and K. O. Beatty, Jr., North Carolina State College, Raleigh, N. C.
*Present address—E. I. du Pont de Nemours & Co., Wilmington, Del.

109 Two-Phase Flow Rates and Pressure Drops in Parallel Tubes
H. L. Folts and R. G. Murray, Goodyear Atomic Corp., Portsmouth, Ohio

110 A Theory of Local Boiling Burnout and its Application to Existing Data
L. Bernath, E. I. du Pont de Nemours & Co., Wilmington, Del.

111 Radiant Heat Transfer Through the Atmosphere
Jin H. Chin* and S. W. Churchill, Univ. of Michigan, Ann Arbor, Michigan
*Present address—The General Electric Co., Cincinnati, Ohio

112 Condensation on a Horizontal Rotating Disc
K. O. Beatty, Jr., North Carolina State College, Raleigh, N. C. S. S. Nandapurkar, Bombay State, India

113 Condensation of a Vapor in the Presence of a Non-Condensing Gas
W. W. Akers, J. E. Crawford* and S. H. Davis, Jr., The Rice Institute, Houston, Texas
*Present address—Magnolia Petroleum Co., Beaumont, Texas

114 Condensation Inside a Horizontal Tube
W. W. Akers and H. F. Rosson*, The Rice Institute, Houston, Texas
*Present address—Univ. of Kansas, Lawrence, Kansas

115 Local Heat Transfer Coefficients and Pressure Drops for Refrigerant-22 Condensing in Horizontal Tubes
M. Altman, General Electric Co., Philadelphia, Pa., R. H. Norris and F. W. Staub, General Electric Co., Schenectady, N. Y.

116 A Large-Scale Plant Analysis of the Colburn and Hougen Analogy
J. F. Revilock, National Carbon Co., Cleveland, Ohio, H. Z. Hurlburt, D. R. Brake, E. G. Lang, Consolidated Chemical Industries Division, Houston, Texas, and D. Q. Kern, D. Q. Kern Associated, Cleveland, Ohio

117 Temperature Distributions in Solids with Electrical Heat Generation and Temperature Dependent Properties

R. P. Stein and M. U. Gutstein, Columbia Univ., New York, N. Y.

118 Determination of Core Dimensions of Cross-Flow Gas-to-Gas Heat Exchangers
P. S. Lykoudis and R. M. Shastri, Purdue Univ., Lafayette, Indiana

119 Heat Transfer Rates for Parallel Flow of Liquid Metals Through Tube Bundles
O. E. Dwyer and P. S. Tu, Brookhaven National Laboratory, Upton, L. I., N. Y.

120 Assessment of Heat Exchanger Data
S. K. Janssen, AB Rosenblads Patententer, Stockholm, Sweden

121 True Temperature Difference of 1-2 Divided Flow Heat Exchanger
D. L. Schindler* and H. T. Bates**, Univ. of Nebraska, Lincoln, Nebraska
*Present address—E. I. du Pont de Nemours & Co., Wilmington, Del.
**Present address—Kansas State College, Manhattan, Kansas

122 Organization of Heat Exchanger Programs on Digital Computers
J. J. Taboruk, Phillips Petroleum Company, Bartlesville, Oklahoma

123 Heat Transfer with Molecular Sieve Adsorbent: II. Heating with Longitudinal Finned Tubes
B. D. Phillips, Linde Co., Tonawanda, N. Y.

124 Heat Transfer with Molecular Sieve Adsorbent: I. Effective Thermal Conductivity
B. D. Phillips, F. W. Leavitt and C. Y. Yoon, Linde Co., Tonawanda, N. Y.

125 Heat Transfer in Baffled, Jacketed, Agitated Kettles
Gary Brooks and Gouq-Jen Su, Univ. of Rochester, Rochester, N. Y.

126 Heat Transfer to a Single Cooling Tube in a Moving Bed Reactor
D. J. Loudin, National Lead Co. of Ohio, Cincinnati, Ohio, K. O. Beatty, Jr., North Carolina State College, Raleigh, N. C.

127 Heat Transfer to Sodium-Potassium Alloy (NaK) in Pool Boiling
Niels Madsen* and C. F. Bonilla**, Columbia Univ., New York, N. Y.
*Present address—Univ. of Rhode Island, Kingston, Rhode Island
**Present address—Puerto Rico Nuclear Center, Mayaguez, Puerto Rico

128 The Thermal Conductivity of Several Plastics Measured by an Unsteady State Method
W. M. Underwood and R. B. Taggart, Monsanto Chemical Co., Springfield, Mass.

Preprints of the above papers may be obtained from the American Institute of Chemical Engineers, 25 West 48th Street, New York 36, New York. They sell for 50¢ a piece. Members of the A.I.Ch.E. or A.S.M.E. Heat Transfer Divisions may purchase the entire set of 28 papers for \$12.00.

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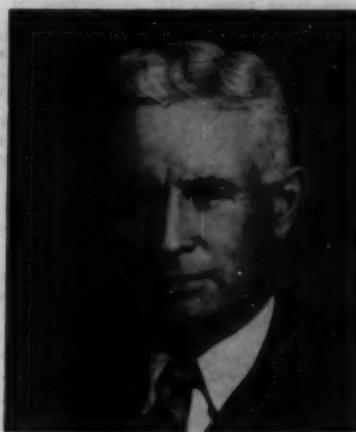
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Heat Transfer Division

Murray honored by Hooker

R. Lindley Murray, chairman of the board and past president of Hooker Chemical, was recently honored when the new \$3,500,000 Research Center of the company at Grand Island, New York, was dedicated to him. A bronze plaque "in appreciation of his devoted services, inspired vision, and untiring efforts since 1916 for the enduring benefit of Hooker Chemical Corporation," will be mounted in the Center's reception foyer.

Starting his career with Hooker in 1916 as research chemical engineer, Murray became president in 1951, and until September 1958 was chief executive officer of the chemical firm.

Murray was a special investigator for the Chemical Warfare Service, and in this capacity was sent to Germany in 1945 to survey the facilities of German plants manufacturing military chemicals. He is the author of several reports on the German chemical situation at that time.



Hooker's Murray—after 43 years a fitting honor.

The recipient of many honors, Murray was twice a director of the Institute. In 1957 he received the Professional Achievement Award of the Western New York Section in recognition of his outstanding engineering and executive ability, and his service to the Section.

New Ch.E. Depts. to be established in Ecuador

Rubens S. Ramalho has been awarded a Fulbright Fellowship to help establish two departments of chemical engineering in Ecuador. Ramalho, a member of the Chemical Engineering Department at Missouri School of Mines and Metallurgy, will be in South America for eleven months beginning in September. During this time he will teach at both the University of Guayaquil and the University of Quito. In the lecture series, attention will be focused on fundamental courses, and on fluid mechanics, heat transmission and thermodynamics. Simultaneously, the university laboratories will be built-up.

Ramalho received his undergraduate training in Brazil, and graduate degrees from Vanderbilt University.

continued on page 150

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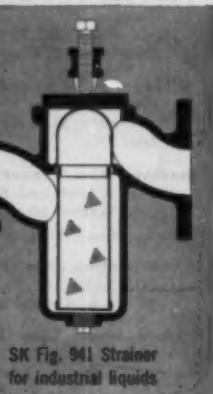
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148 July 1959

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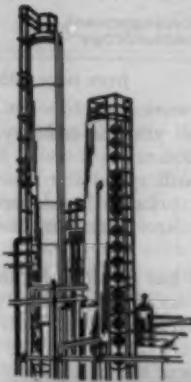
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CHEMICAL ENGINEERING PROGRESS, (Vol. 55, No. 7)

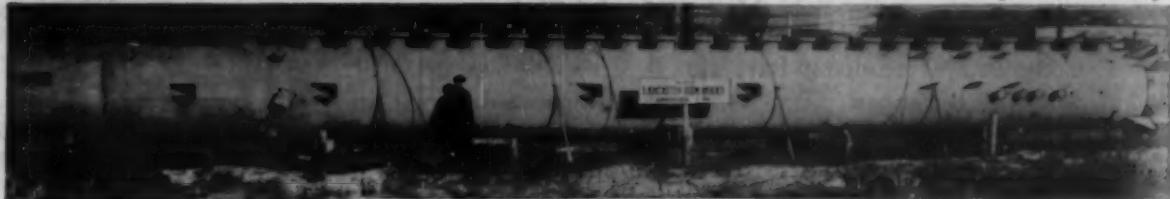
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people in management
& technology

from page 148

In addition to his work as an educator, he has had several years in industry, designing oil refineries.

The educator will spend the summer of this year, prior to his departure, in Syracuse, New York, with the General Electric.

W. W. Grigorieff has returned to his position as chairman of the University Relations Division, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee. He spent the past year on leave-of-absence while serving with the Exchange and Training Division of the International Atomic Energy Agency in Vienna.

Julius T. Banchero has been appointed head of the Department of Chemical Engineering at Notre Dame, effective September 1. Currently in the chemical and Metallurgical Engineering Department at the University of Michigan, he also taught at the University of Detroit. A specialist in unit operations and process design, Banchero has conducted extensive research in the field of heat transfer, and, in addition, served as consultant to industry.

Wheaton W. Kraft, vice president of Lummus Co., has been named chairman of a sectional committee of the American Standards Association. He represents the Institute, which is administrative sponsor of the project. The newly formed committee, concerned with chemical engineering for the nuclear field, is one of several established for the development of industrial and safety standards for the nuclear industry under the auspices of ASA.



Eugene R. Smoley retires as vice president of the Lummus Co. after twenty-five years of service. He will continue to serve the company on a part time basis as a sales consultant. Smoley will also continue his work with A.I.Ch.E., for which he has just completed two years as national program chairman.

Max Strawn joined the Project Engineering Department of American Cyanamid's Engineering and Construction Division. He has been assigned to the gas conversion, nitric acid, and ammonium nitrate project at the company's plant in Welland, Ontario. Strawn is currently a member of A.I.Ch.E. national admissions committee, and chairman of the New York Section.

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Crawford H. Greenewalt received the Gold Medal of the American Institute of Chemists for 1959. The citation was for his outstanding leadership in the chemical industry, and his effective support of professional dignity and individual initiative. Greenewalt is the tenth president of Du Pont, which he joined in 1922 as a chemist. Among his foremost achievements was the development of a commercial process for making hosiery yarn from nylon.

Albert Cholette appointed editor of the *Canadian Journal of Chemical Engineering*. He is chairman of the Department of Chemical Engineering at Laval University.

Val Kudryk has been appointed director of research and development of Accurate Specialties, Woodside, New York. Kudryk will head up a development program on new high purity alloys and components for the electronics industry. He was formerly assistant to the vice president and chief engineer of Nichols Engineering.



L. C. Kemp, Jr., a director of the Institute, moves over to the position of vice president of the Research and Technical Department at Texaco. Kemp, who has been with the company for thirty years, was formerly vice president in charge of the Petrochemical Department.

A. J. Johnson celebrated thirty years of service with Shell. Now vice president, Development and Engineering Division, Shell Development's Emeryville Research Center, he began his career at the refinery at Norco, La. Development and design of one of the first synthetic glycerine plants was under Johnson's direction.

Edward T. Wilhelm assumes post of works manager of Central Soya Co.'s Chicago Laramie Avenue plant, Chemurgy Division.

Robert L. Irvine is now a consultant in the economic analysis, managerial and technical areas, located in New York city. He was formerly head of research, manufacturing and oil supply, Arabian American Oil Co.

continued on page 154

a filter man's thinking

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CHEMICAL ENGINEER-B.S. Experienced in plant design and construction cost estimation and economic evaluation, direction of research and development programs and plant operations. Vinyl and synthetic rubber polymerization, extrusion, chlorination and esterification. Age 37. Wish to relocate with company offering greater opportunity for increased income. Box 11-7.

CHEMICAL ENGINEER-P.E., B.S. 1949, age 37, two years' pilot plant, four years' development, four years' production. Presently employed. Desire a responsible position in Development- or Production-Administration, or University Chemical Engineering Instructor. Box 12-7.

CHEMICAL ENGINEER-B.S. 1951, P.E. experience in petrochemical production, process trouble shooting, process improvement, and cost reduction. Desire broader responsibility in production development and management with opportunity for advancement. Prefer northeast location. Box 13-7.

PLANT SUPERINTENDENT-registered professional engineer (Ch. E.). Twelve years' industrial experience includes inorganic and organic chemical manufacturing and consulting instrumentation. Desire chemical plant or production management position. Salary \$12,000. Age 38, married. Box 14-7.

CHEMICAL ENGINEER-about eight years' experience, B.Ch.E. degree, graduate credits, single, 38. Experienced in pilot plant operations, development, plant and equipment design, fluid flow, heat transfer, data analysis, some instrumentation. Give location, type of work, etc. Box 15-7.

CHEMICAL ENGINEER-B.E. 1951, P.E. age 32, three years production supervision, trouble shooting. One and a half years' economic studies, evaluation, two years' construction design, two years' project engineer. Married. Will relocate. Box 16-7.

CHEMICAL ENGINEER-B.S. Ch.E. 1957. Age 27, married, draft exempt. Desire position in a process industry in production supervision or process development. Presently employed by a chemical equipment manufacturer as pilot plant supervisor. Ultimate goal—management. Box 17-7.

PARTNERSHIP—(or promise of partnership) in established engineering firm desired by aggressive management-minded chemical/mechanical engineer. Twelve years' varied domestic and foreign experience plus business studies; refineries, petrochemicals, air conditioning, industrial facilities. Could invest \$50,000. Tau Beta Pi. Southern location only. Box 18-7.

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CHEMICAL ENGINEER-Ph.D., 36, nine years' diversified experience in research management, organic chemical process development, applications of nuclear energy, catalyst and kinetic studies, technical and economic surveys. Desire senior position in process development with chemical manufacturer. Box 20-7.

SITUATIONS OPEN

(continued from page 152)

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SITUATIONS WANTED

(continued from page 152)

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PRODUCTION CONTROL MANAGEMENT—Age 35, married. B.S.Ch.E. Nine years' water treatment and corrosion control, three years' lubricants manufacture. Wish position with future, in water treatment, corrosion field, in midwest area preferably. Box 24-7.

EXECUTIVE ENGINEER—M.S.Ch.E. 1948. Eleven years' varied experience project engineering, technical sales and service, field of fuels, plastics, heavy chemical equipment—extensive world wide travel. Desire challenging position with management potential. Box 25-7.

(continued on page 154)

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154 July 1959

people in marketing

from page 151

George A. Green appointed sales manager, eastern region, Scientific and Process Instruments Division Beckman Instruments. His office will be in Mountainside, N. J.

Peter W. Hill has joined Houdry Process Chemical Sales Department. For seven years a member of the research and development lab, he will concentrate on market research in his new position.

 William H. Hollen takes over the position of chemical products field sales engineer at National Carbon (Union Carbide). With headquarters in St. Louis, Hollen will be responsible for sales engineering in several states.

Donald V. Brown moves up into the position of manager-sales development at GE, Silicone Products Department. Brown, previously a specialist in marketing research for the department, will continue to be located at Waterford, N.Y. J. C. Trinastic has joined Diamond Alkali. He will do market research in the Commercial Development Department. Trinastic was previously with Monsanto for several years, most recently working on research-engineering liaison for AEC projects.

Anthony P. Chavent, technical representative in the Sales Department at Union Carbide Chemicals, has been transferred to the Boston district from Cincinnati.

NECROLOGY

Alan T. Ossermann, 37, process engineer, W. R. Grace & Co. He was formerly research engineering supervisor at Davison Chemical Division, Baltimore, Md.

Haskell Peddicord, 37. Associated with Procter & Gamble for twelve years, Peddicord became associate director of the Paper Products Development Division with its inception two years ago. He was formerly development engineer. Chairman of the Ohio Valley Section of the Institute last year, Peddicord originated the program, under-written by Procter & Gamble, of student chapter awards which enables student members to attend annual meetings of A.I.Ch.E. Begun with the Boston meeting in 1955, the sponsored student program had some 80 students from eighteen schools attending the 1958 annual meeting of the Institute.

SITUATIONS WANTED

(continued from page 153)

PRODUCT DEVELOPMENT EXECUTIVE—M.S.Ch.E. Experience in food and chemical industries. Development of new products and processes, evaluation of commercial possibilities, location of raw material supplies, pilot plant development, manufacturing plans, quality control. Box 26-7.

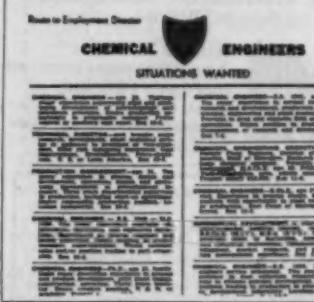
PROJECT PROCESS ENGINEER—B.S.Ch.E. 1941. Experienced in petroleum, petrochemicals, including gas purification, ammonia, low temperature. Detailed knowledge distillation, evaporation, fluidization. Basic patents and articles. Desire project manager position in East. Box 27-7.

SALES ENGINEER—M. S. Degree. Six years' of experience in process development, chemical and mining process equipment and project sales overseas, marketing experience. Several foreign languages. Seek position as Sales Engineer or representative preferably covering overseas territory, but will consider N. Y.—Conn.—N. J. area. Box 29-7.

PRODUCTION ENGINEER—B. S. '30. Age 32. Nine years' varied experience all phases radiochemical processing "Q" clearance. Box 30-7.

NON-MEMBER

PLANT ENGINEER—B.S.Ch.E. 1942. Process and equipment design, construction and maintenance supervision. Reasonable salary requirements. Box 28-7.



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Dallas 18—Richard E. Holzman, Dist. Mgr., 9006 Capri Drive, Diamond 8-1229.	
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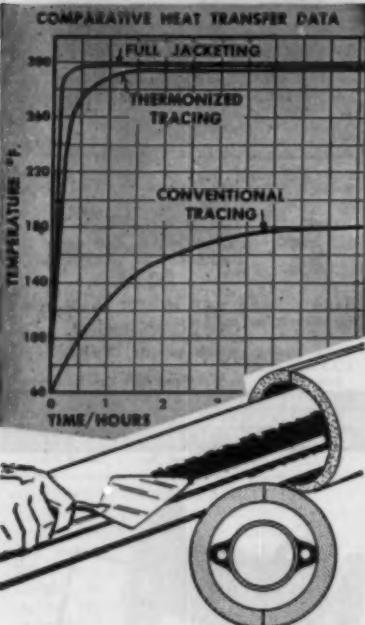
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156 July 1959

News and Notes of A.I.Ch.E.

New Directory—Our biennial has bloomed again. In May we received from the printer the Directory for 1959, and copies of it have been sent to every committee member, Local Section officer, and Student Counselor. Any member of A.I.Ch.E. who wishes a copy need only drop a post card to me requesting one.

Council Actions—The Council meeting at Kansas City brought with it many important actions, since it was a culmination of a long period of development of the A.I.Ch.E.

It is difficult to determine what was the most important action taken, but certainly high on the list should be the appointment of the Committee on Dynamic Objectives for Chemical Engineering. Essentially this is an attempt on the part of the chemical engineering profession to answer many of the questions that have arisen over the past 10 to 15 years on where chemical engineering is going. In recent years the unit operations have been merging and the clear-out lines between each operation are slowly disappearing. New techniques and tools are coming to the front, and, in order for the Institute to act efficiently in the new chemical engineering areas of molecular research and others, Council believes

employment Section, two free insertions being permitted annually. For several years this Classified Section has been mailed, as soon as proof sheets are available, to a long list of personnel and management officers. On top of this, we are printing a booklet for A.I.Ch.E. members entitled *Employment Pointers for Chemical Engineers*, and we will begin collecting employment statistics from members. Several other plans are also being investigated in the employment area.

Registration policy is another important action recently taken by Council. A full text of the policy statement was mailed a number of weeks ago to every committee member, Local Section officer, and Student Counselor, so that the exact wording might reach early a hard core of interested members. All members can read it on page 17 of this issue. In essence, Council is confirming its previous stands on registration; that is, it is opposed to compulsory registration of all engineers and reaffirms that neither the kind of business organization nor its size has anything to do with professional responsibility or competence. Council again insists that professional responsibility is personal. It has, however, added to its policy the statement of a practice that has been followed by A.I.Ch.E. for some time: it urges all engineers to become registered as soon as practicable after entering the profession. The reasoning behind the statement is that engineers never know when they may need registration for some project involving public safety.

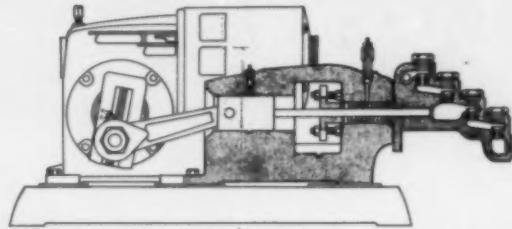
New Bylaws for Local Sections—For established Local Sections about to revise their bylaws or for groups about to organize a Local Section, revision of the Model Local Section Bylaws by Council will be of interest. One of the big changes recommended concerns the name of Local Section members who are not A.I.Ch.E. members. Heretofore they were usually known as *affiliate* members, but this caused confusion with A.I.Ch.E.'s Affiliates. The new designation of these members is recommended to be *Local Member* or *subscribing, sustaining, collaborating, cognate, adjunct, etc., member*.

F.J.V.A.

HOW TO METER ACIDS ACCURATELY AGAINST PRESSURE

Corrosive liquids present two major obstacles to achieving maximum metering accuracy, economy, and safety. For one thing, corrosion can introduce an intolerable ever-changing volumetric error. For another, corrosive liquids must be retained by the pump at all times. Leakage can endanger personnel and necessitate the premature replacement of pump parts and associated equipment.

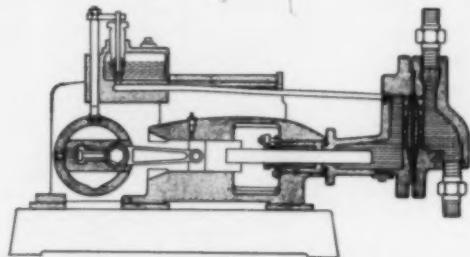
But both obstacles can be successfully overcome. First by choosing the right pump for the metering job at hand. Second, by making sure that all wetted parts of the pump chosen are inert to the liquid being metered. Here are some ideas based on practical acid metering experience that may help you to choose the one best controlled volume pump for your metering needs.



Packed Plunger Pumps

For the majority of mildly corrosive liquids, low cost packed plunger pumps have proved themselves entirely adequate. Some thirteen materials of construction are standard on packed plunger pumps, running from cast iron to Hastelloy B and C, more than enough to satisfy mild corrosive metering requirements. Capacities to 2056 gph, pressures up to 50,000 psi.

An added tip: Standard Milton Roy motor driven pumps in corrosive service can be equipped with "catch-all" yoke type gland followers.



Diaphragm Liquid Ends

When the liquid to be metered is highly corrosive or otherwise dangerous, a controlled volume pump with diaphragm liquid end is the best choice. A plastic or

If precision pumping of dangerous chemicals is one of your problems, look again to Milton Roy's 25 years of experience for your most economical solution. Write for a general introduction to controlled volume pumping in Bulletin 553-1. Milton Roy Company, 1300 East Mermaid Lane, Phila. 18, Pa.

Controlled Volume Pumps • Quantichem Analyzers • Chemical Feed Systems

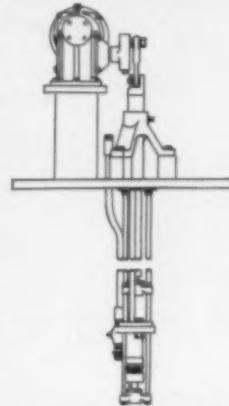
stainless steel diaphragm positively separates the process liquid and the plunger. The plunger displaces a hydraulic fluid which in turn strokes the diaphragm to create pumping action through the ball checks. Consistently high accuracy is achieved through unique design features. As the illustration shows, positive mechanical action bleeds any air or vapor from the hydraulic side between strokes and corrects liquid volume if necessary. Internal liquid end design also automatically eliminates bubbles from the process liquid side.

Very often, a pump chosen for mild corrosive service is obsoleted by a process change specifying a more highly corrosive liquid. But this waste is neither necessary nor desirable. The diaphragm liquid end illustrated can easily be substituted for the conventional liquid end on any standard motor driven controlled volume pump, bringing the entire metering system up to date at little extra expense. *Designs of this type will handle up to 400 gph against heads to 2700 psi.*

Totally Immersed Liquid Ends

Special metering problems demand special pump designs. For example, acids with high vapor pressure or high specific gravity must be pumped with limited suction lifts and generally require suction heads. The ideal answer is the standard Mersemetric® controlled volume pump. Pump drive and motor are mounted on the tank top, but the liquid end is completely submerged to a depth of up to fourteen feet. This same design feature also eliminates the need for tank connections below liquid level, and permits chemicals to be metered directly from storage.

The maximum safety-minimum handling Mersemetric design is just about standard for metering sulfuric acid for demineralizer regeneration and pH control of cooling tower water and deaerator effluents. *Capacities up to 218 gph, pressures up to 1200 psi.*

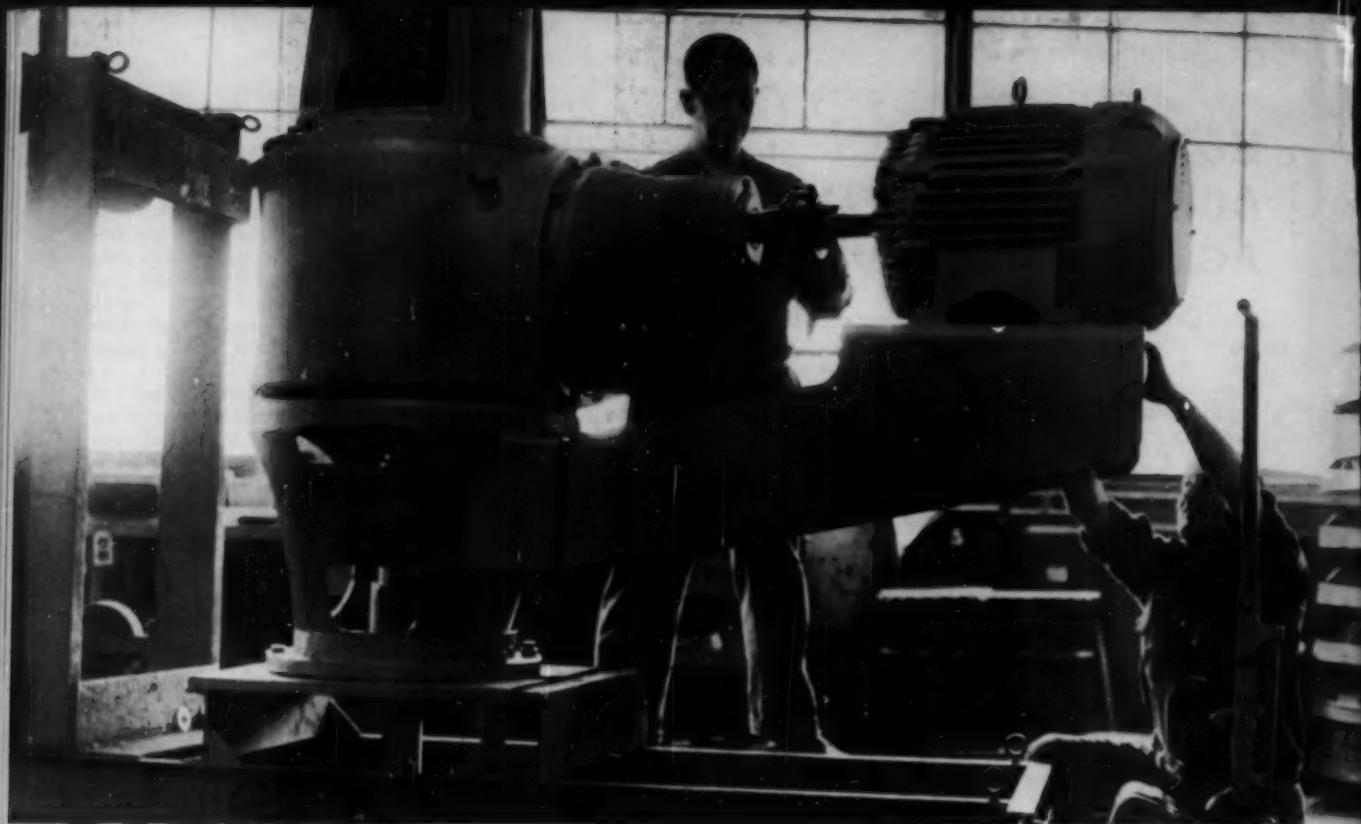


The Acid Metering System

You can be fairly sure of making the right choice only if you consider all the factors. Here's a convenient checklist of a few points that are often overlooked:

- Is the entire system corrosion-resistant . . . storage tank, suction and discharge piping, controlled volume pump, and relief valve?
- Have you thoroughly considered the physical properties of the liquid? High vapor pressure or high specific gravity liquids may demand a suction head.
- Have you considered plant and personnel safety under all possible conditions?
- Have you considered maintenance as well as first cost in determining the economics of the system?





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Instead of waiting months, you can now have one—or several—ready to put on your tanks *in a few weeks!*

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Ratings range from 40 hp to 150 hp with double-reduction gearing, and from 10 to 50 hp with triple reduction.

You also get these time-proved LIGHTNIN Mixer advantages—*at lower*

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You can get the "5" Size LIGHTNIN Mixer in standard assemblies—and in special designs—for open or closed tanks; with stuffing box or with quickly replaceable LIGHTNIN rotary mechanical seal for pressure and vacuum mixing.

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For details, call your LIGHTNIN Mixer representative now. You'll find his name in Chemical Engineering Catalog. Or write us direct.

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MIXER SHAFT FLEXIBLY COUPLED TO SPEED REDUCER. Mixer shaft passes through hollow quill. Shaft and quill are connected only by a flexible coupling (not shown). Shock loads on shaft are absorbed by coupling—cannot reach gears.



